DOCUMENT RESUME

ED 222 355 SE 039 406

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TITLE Coal: Fuel of the Past, Hope of the Future. A Basic Teaching Unit on Energy. Revised.
INSTITUTION Nebraska State Energy Office, Lincoln.
PUB DATE Feb 81
NOTE 70p.; Original writer, Dianne J. Kennedy. For related documents, see ED 179 395 and SE 039 407-416.
AVAILABLE FROM Nebraska Energy Office, Extension Division Chief, P. O. Box 95085, Lincoln, NE 68509 ($5.00).

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *Coal; Conservation Education; *Energy; Energy Conservation; Environmental Education; High Schools; *Learning Activities; Mining; *Science Activities; Science Education; *Secondary School Science; *Social Studies
IDENTIFIERS *Energy Education; Nebraska

ABSTRACT

Recommended for grades 9-12 science and/or social studies classes, this 13-14 day unit is designed to allow students to explore coal and its properties, examining the nature of coal, where it is found, materials made from coal, and the role of coal in the past and its promise for the future. The unit consists of 11 activities with rationale, objectives, and instructional strategies provided for each activity. Many of the activities contain an informational reading which provides basic information about a particular topic or issue (with Fry readability levels for each reading indicated in the introduction). Following the readings, students answer questions about the readings, design graphics, interpret data, try experiments, and research various aspects of coal. A teacher's guide for a slide program (The North Omaha Coal Fired Plant) which can be ordered from the Nebraska Energy Office is also included. (Author/JN)

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COAL: FUEL OF THE PAST HOPE OF THE FUTURE

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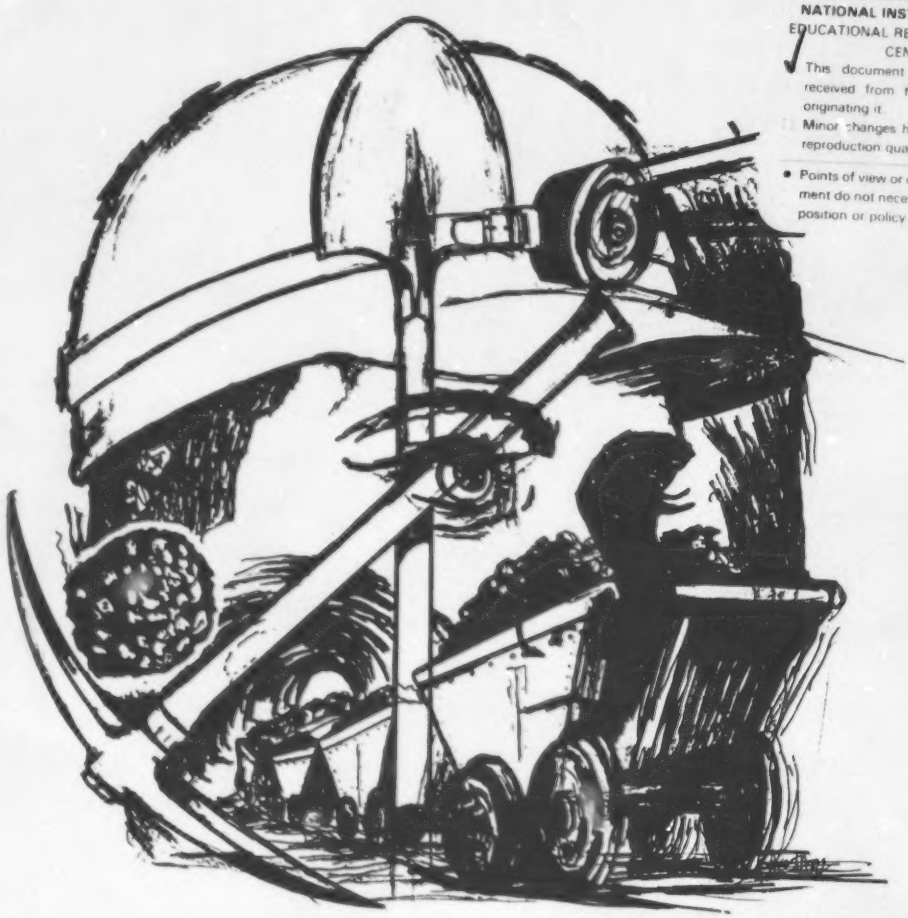

Revised and Edited by
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Prepared for:
The Nebraska Energy Office

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A Basic Teaching Unit on Energy

nebraska energy office

SE 039 406

Coal: Fuel of the Past, Hope of the Future

Original Writer

Dianne J. Kennedy

Prepared for:

The Nebraska Energy Office

ACKNOWLEDGEMENTS

The original "Basic Teaching Units on Energy" consisted of a package of 30 instructional packets contained within three volumes. The original fourteen units were written at the University of Nebraska-Lincoln, under auspices of the Nebraska Energy Office, by Nebraska teachers participating in a three-week Faculty Development Institute sponsored by the U.S. Department of Energy (summer, 1978). The units were edited by the following individuals:

—Dr. Donald McCurdy, Professor of Science Education, University of Nebraska-Lincoln;
—Mr. Gary A. Lay, Education Coordinator, Nebraska Energy Office; and
—Dr. Robert Reeder, Science Department Chairman, East High School, Lincoln, Nebraska.

An additional eight units were written by independent authors in the summer of 1979 and the final eight units were developed as a result of a second federal grant (summer, 1980).

The present format has been achieved as a result of an evaluation conducted by the Nebraska Energy Office, February, 1981. Rather than continue to offer all 30 units as a single package, the Nebraska Energy Office determined to revise, edit, and typeset the 10-12 highest quality units and continue to offer the other units in their present format.

The editors of these revised "Basic Teaching Units" wish to thank the individual writers, original editors, and clerical staff for their contributions in creating the "Basic Teaching Units" series.

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TO THE INSTRUCTOR . . .

"Coal: Fuel of the Past, Hope of the Future" is a unit designed to allow students to explore coal and its properties. They will examine: What is coal? Where is it found? What is made from coal? What was coal's role in the past and what is its promise for the future?

You, the teacher, need to review and select those activities appropriate for your class. The reading levels are stated for each reading. This reading level is based on the number of syllables per hundred words and number of sentences per passage. This technique is taken from "A Readability Formula That Saves Time," Edward Fry. Journal of Reading, April, 1963, Volume II, No. 7, pp. 513-16 and 575-578. These reading level estimations will allow teachers the opportunity to perform some pre-reading exercises on vocabulary and concept development.

It is the intent of the Nebraska Energy Office to provide you with as much information on this topic as well as any other energy source. You are encouraged to use the ordering page attached to this unit to order additional resources.

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Coal: Fuel of the Past, Hope of the Future

Abstract

This unit contains eleven different activities for students. Many of the activities contain an informational reading which provide basic information about a particular topic or issue. Following the readings, students answer questions about the readings, design graphics, interpret data, try experiments, and research various aspects of coal. Also attached is a teacher's guide for a slide program which can be ordered from the Nebraska Energy Office.

Recommended Level

Grades 9-12

Academic Areas

Science or Social Studies

Readability Ratings (Fry)

"The Need for Coal" 11th year
"Coal" 10th year
"Chemical Composition of Coal" (unable to rate)
"How Coal is Mined" 8th year
"Coal: Always a Bridesmaid" 11th year
"Coal: Abundant Resource, Abundant Problems" 10th year
"Liquid from Coal" 12th year
"Gas From, Coal—How Is It Done?" 11th year

Time Required

13-14 days

Process Skills

—Analyzing	—Graphing	—Locating
—Designing	—Hypothesizing	—Observing
—Discussing	—Identifying	—Reading
—Experimenting	—Interpreting	—Testing

Advanced Teacher Preparation

Obtain: North Omaha Coal Fired Power Plant slide set from the Nebraska Energy Office or your local Educational Service Unit.

Read: Energy Info—A Directory of Publications and Audio Visual Material from the Nebraska Energy Office

1. Students will gain an awareness of how coal was formed and its importance as a fossil fuel in our history and culture.
2. Students will gain an awareness of where coal is located and how it is mined.
3. Students will gain an understanding of coal's use as a bridge to future energy sources.
4. Students will become aware of the possible environmental problems associated with coal.

Student Objectives

These are included in each activity.

Planning Guide

Day 1	
Activity #1	"The Need for Coal"
Day 2	
Activity #2	"Coal"
Day 3	
Activity #3	"A Laboratory Simulation of Coal Formation"
Day 4	
Activity #4	"Chemical Composition of Coal"
Day 5	
Activity #5	"U.S. Coal Deposits"
Day 6	
Activity #6	"How Coal Is Mined"
Day 7	
Activity #7	"Collecting Methane Gas"
Day 8	
Activity #7	continued
Day 9	
Activity #8	"Coal: Always a Bridesmaid"
Day 10	
Activity #9	"Coal: Abundant Resource, Abundant Problems"
Day 11	
Activity #10	"Liquids From Coal"
Day 12	
Activity #11	"Gas From Coal—How Is It Done?"
Day 13	
Slide Presentation	"The North Omaha Coal—Fired Power Plant"

Evaluation Suggestions

Evaluation of these activities depends on how each activity is used and is therefore up to the individual teacher. As a suggestion, however, each student could be given a written test composed of two or three selected questions from each of the activities.

In addition, possible questions to be used as a part of the evaluation could be:

1) How is lignite different from anthracite and bituminous coal?

2) Explain the differences between "surface" mining and "underground" mining.

3) What are some environmental problems with coal?

4) Why is coal considered as a "bridge" to the future?

5) What are other types of fuel which can be made from coal? Explain their differences.

Instructor Information...

"The Need for Coal"

Rationale:

The WOCOL was a study of the world's coal supplies by several countries. This particular excerpt examines the world's dwindling sources of oil and forecasts the importance coal will play in the next 20 to 30 years.

Objectives:

Students will be able to identify several energy resources.

Students will be able to read and discuss coal's importance in the energy picture.

Students will be able to recall information and answer questions about the reading.

Implementation:

This particular activity could be very useful for group discussion purposes. Students could read the excerpt "The Need for Coal" and discuss what this report means for the United States. The student worksheets can be used as a follow-up activity or a single copy could be used in directing the group's discussion.

Debriefing:

This will occur through oral discussion. The follow-up questions can also be used to check reading comprehension. This activity provides page numbers for the location of answers for those who may have difficulty in scanning for answers.

Name_____

Date_____

The Need for Coal

COAL

the central message

ESTIMATED RECOVERABLE COAL RESERVES

United States:	30.8%
USSR:	23.1%
Europe:	21.4%
China:	13.5%
Rest of Asia:	3.0%
Oceanic:	4.2%
Africa:	2.6%
Canada:	0.9%
Latin America:	0.5%

action is necessary **now**

environmental protection

Why coal?

The world has reached the end of an era in its energy history. Increased supplies of oil, which have been the basis for economic growth in the past few decades, are not expected to be available in the future. The development of a new energy basis for continued economic growth has therefore become an urgent necessity. Building a bridge to the energy sources and supply systems of the next century — whatever they turn out to be — is of crucial importance. We believe that coal can be such a bridge and that it will also continue to serve a vital role into the longer-term future.

A tripling of coal use and a 10-15 fold increase in world steam coal trade would allow the energy problems of the next two decades to be faced with confidence. With such increases in coal use, coupled with a mobilization of other energy sources and vigorously promoted conservation, it becomes possible to see how to meet the energy requirements of moderate economic growth throughout the world. But without such a coal expansion the outlook is bleak. This is the central message of our report.

In the industrialized countries coal can become the principal fuel for economic growth and the major replacement for oil in many uses. Coal may also provide the only way for many of the less developed countries to obtain fuel needed for electric power and industrial development, and to reduce their dependence on oil imports.

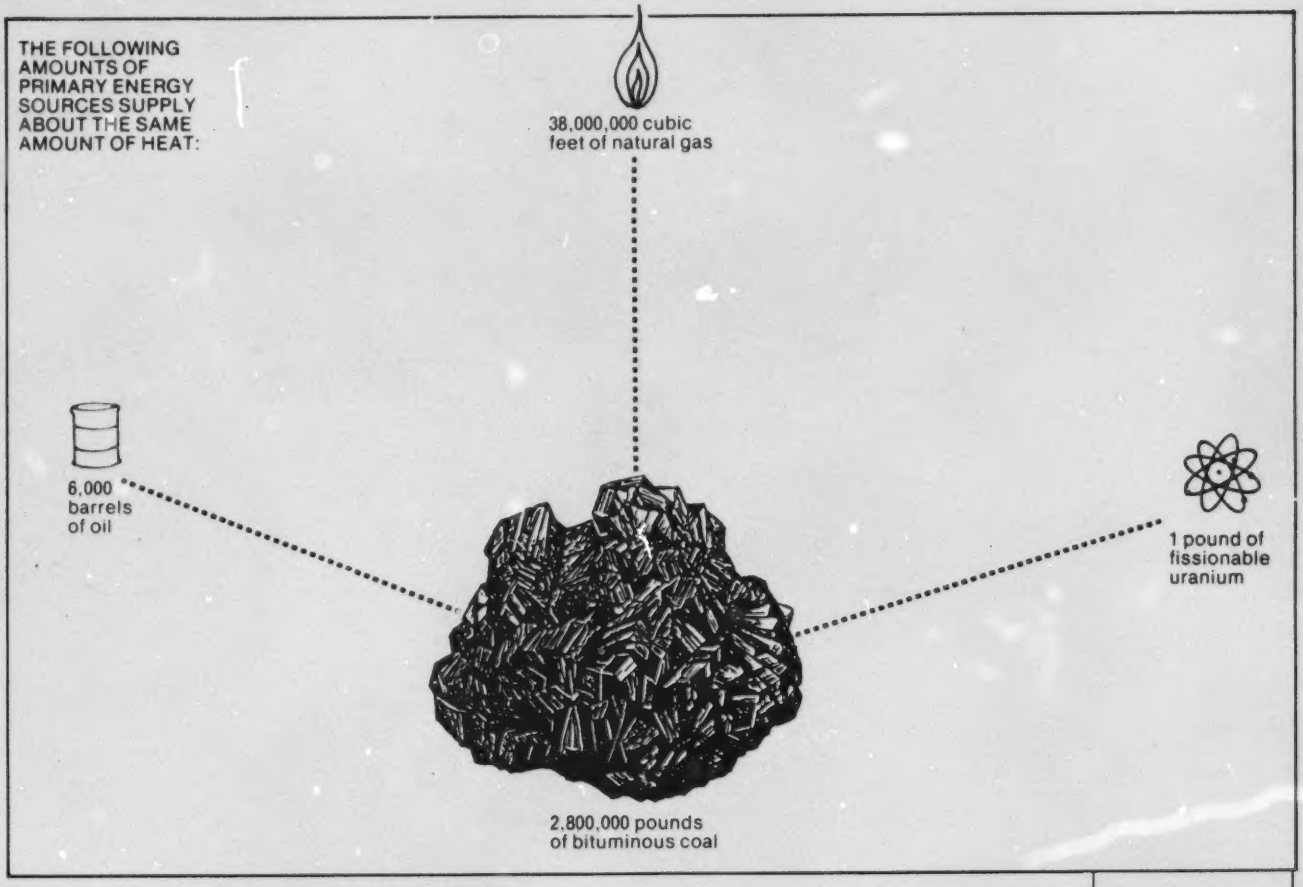
Increased use of coal will require large investments, but no greater than those required for other fuels such as oil, gas, and nuclear energy. Countries now heavily dependent upon oil must build coal-using facilities on a large scale before they can use the coal they will need. Power stations, coal ports, railways, and handling facilities take a long time to plan and build. So do mines and export terminals. Unless decisions to build them are made soon, these facilities will not be ready by the time when this study indicates that they will be acutely needed. It is necessary for governments and industry to act cooperatively so that the required investment decisions are made promptly.

Unlike oil, the reserve base for coal is sufficiently great to support large increases in production for a long time into the future. Moreover, the technology for its safe and environmentally acceptable production, transport, and use is provided and already widely applied in most areas.

We have examined questions with great care and considered the measures that would have to be taken within each **WOCOL** country to comply with present and anticipated environmental regulations. The technology exists by which exacting standards of environmental protection can be met, and much work is being done to improve it and lower its costs. We are convinced that coal can be mined, moved and used at most locations in ways that meet high standards of environmental protection at costs that still leave coal competitive with oil at mid-1979 prices.

The present knowledge of the effects on climate of carbon dioxide (CO_2) from fossil fuel combustions does not warrant a global reduction in fossil fuel use or a delay in the expansion of coal. However, support for research on the possible effects of increased atmospheric (CO_2), including that or global warming, is essential so that future policies may reflect an improved understanding of such matters.

Coal is not in competition with conservation, nuclear or solar energy, or other sources as the sole solution to the world's energy problems. All these will be required if the energy needed is to be supplied. The world, however, needs an incremental energy source as nearly like oil as possible, but with the vital difference that it will be obtainable in increasing amounts until well into the next century. Ideally, and if it is to fill the role played by oil over the past decades, it should be versatile in application, easily transported and stored, and reasonably priced. The technology for using it should be mature and generally available so that it can be brought into use rapidly, widely, and safely. It should be capable of satisfying strict environmental standards with presently available technology and at a cost competitive with other fuels. It should be obtainable in large quantities and for long enough to justify the investments required to bring it into widespread use. Only coal comes close to meeting these specifications.


THE FOLLOWING AMOUNTS OF PRIMARY ENERGY SOURCES SUPPLY ABOUT THE SAME AMOUNT OF HEAT:
38,000,000 cubic feet of natural gas
6,000 barrels of oil
1 pound of fissionable uranium
2,800,000 pounds of bituminous coal

This need for coal has been recognized many times, perhaps most clearly and conclusively in the resolution adopted at the Seven-Nation Economic Summit at Tokyo in June, 1979:

> We pledge our countries to increase as far as possible, coal use, production, and trade, without damage to the environment. We will endeavor to substitute coal for oil in the industrial and electrical sectors, encourage the improvement of coal transport, maintain positive attitudes toward investment for coal projects, pledge not to interrupt coal trade under long-term contracts unless required to do so by a national emergency, and maintain, by measures which do not obstruct coal imports, those levels of domestic coal production which are desirable for reasons of energy, regional and social policy.[1]

The International Energy Agency has also been strongly supportive of greater coal use and has adopted a statement of "Principles of IEA Action on Coal," agreed upon steps designed to increase the use of coal, and has created a high-level Coal Industry Advisory Board (CIAB) to assist in the practical implementation of these principles.

Declarations of intent are, however, not self-executing. They require action. We believe that a deeper public understanding of the importance of coal to the world's future is necessary if the numerous steps by local, regional, and national governments, by international agencies, and by public and private investors are to be taken in time to allow expanded use of coal to provide a major part of the energy required for the world's continued economic growth.

WHERE WE GET OUR ELECTRICITY

Coal 48%
Gas 15%
Oil 14%
Hydro 12%
Nuclear 11%

public understanding

[1] Abstract from Tokyo Communiqué of Seven-Nation Economic Summit, June, 1979. Countries included Canada, France, the Federal Republic of Germany, Italy, Japan, the United Kingdom, and the United States.

world energy prospects

worsening outlook for oil

During the past two decades world oil consumption has grown twice as fast as that of all other sources combined. Two-thirds of the growth in energy consumption in the member countries of the Organization for Economic Cooperation and Development (OECD) came from oil during this time. In western Europe and Japan, in fact, oil has provided over 80 percent of this increase in energy use. In all but a few of the developing countries, oil has also supplied virtually all of the increase in energy consumption. It is a matter of considerable concern therefore that there now appears to be no realistic prospect of meeting any substantial part of future increases in the world's energy needs.

The present international oil trade amounts to about 35 million barrels a day (mbd), which is about 55 percent of the world's total oil consumption. Of that amount about 80 percent is exported by OPEC countries, and more than 20 mbd flow through the straits of Hormuz on the Persian Gulf. It is this concentrated and vulnerable flow of oil from the OPEC countries that has provided virtually all flexibility within the world's energy system since 1960.

There are no secure grounds for assuming that OPEC production of oil will increase in the future, and there are good reasons to fear it may be less. As the Iranian revolution has shown, political change can be rapid and unexpected; and there are many other tensions, particularly in the Middle East, that are unlikely to be resolved soon.

OPEC policy

Moreover, key producers, such as Saudi Arabia and Kuwait, have adopted policies that will conserve oil in the ground as a better security for their future than the income they cannot spend or usefully invest. It is now the declared policy of OPEC member countries to limit oil production to amounts that will total no more than the present level of about 30 mbd. This policy is directed toward optimizing rather than maximizing revenues. The goal is to generate only as much revenue as their economies can handle without causing too rapid social change and high inflation. Increasing prices while holding production stable, or even reducing it, meets this financial objective and at the same time conserves old reserves.

OPEC Countries
1. Algeria
2. Ecuador
3. Gabon
4. Indonesia
5. Iran
6. Iraq
7. Kuwait
8. Libya
9. Nigeria
10. Qatar
11. Saudi Arabia
12. United Arab Emirates
13. Venezuela

There is nothing unexpected or mysterious about this. The signs have been visible for some time. In 1977, the WAES report, **Energy: Global Prospects 1985-2000**, the direct predecessor of this study, pointed to the problems likely to arise from a decision by OPEC members to restrict all production in the early 1980's. It said that such an early limit could impose severe strains on all consuming countries. It is almost certain that the resulting shortfall in energy supply would lead to a significant price rise. This might trigger a world recession that would increase unemployment in many or all industrialized countries and severely damage the economics of the developing countries. This is what is happening, but it is occurring a few years sooner and with a production ceiling lower than expected.

dwindling oil supplies

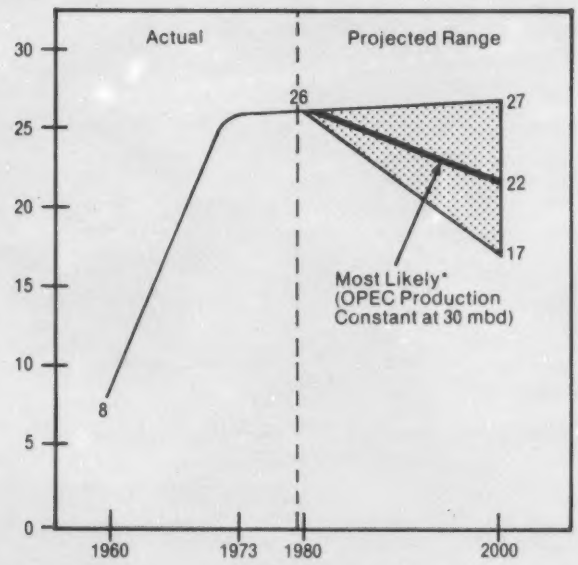
Prospects for increased oil supplies from non-OPEC areas are not sufficiently encouraging to change this picture. Production from fields in the North Sea and Alaska's Prudhoe Bay are projected to peak and level off in the next few years. It appears that Mexico and Norway will continue to limit exports to meet revenue needs. Increases in oil production in the People's Republic of China and the developing countries will be largely used to meet growing domestic demand. Furthermore, some experts have suggested that production in the Soviet Union, which now exports 1 mbd to countries outside Eastern Europe, is leveling off, and that the Soviet Union/Eastern Europe area is therefore unlikely to remain self-sufficient in oil.

Oil

For all these reasons, we believe that oil will provide, at most, a small fraction of any future increase in world energy needs. Indeed, the availability of oil for import by the OECD nations is likely to be less in the year 2000 than today.

The specific amount of oil available to OEDC member countries will depend on a number of factors. There are a range of projections, about production and domestic consumption of oil by OPEC member countries, oil exports from other countries, and oil import requirements of other regions including the developing countries and the centrally planned economy countries. These assumptions lead to a projected range of net oil imports available to the Organization for Economic Cooperation and Development (OEDC) which we have illustrated in Figure I-1. The most likely projection within that range is for a gradual decline in imports from 26 mbd in 1978 to about 22 mbd by the year 2000. The world must find ways other than oil to provide the additional energy required for its future economic growth.

Figure I-1 Range of Net Oil Imports Available to OECD Countries (1960-2000)



*Corresponds to assumptions of (1) constant OPEC oil production of 30 mbd, (2) an increase in OPEC internal oil consumption from 2.2 mbd in 1978 to 5 mbd in 2000, (3) a decrease in net CPE oil exports from 1.0 mbd to 0 mbd from 1978 to 2000, and (4) constant net oil imports of 3.2 mbd from 1978-2000 for other countries outside the OECD. Other combinations of assumptions could yield similar results on net oil imports available to OECD countries.

natural gas and liquefied natural gas (LNG)

Natural gas provides a substitute for many uses of oil. World reserves are as great as those for oil, whereas use is at present much less. But in some areas where natural gas is already produced and used on a large scale, such as the United States and parts of Western Europe, expansion is already being curtailed as consumption exceeds new discoveries. Imports of gas by pipeline or as liquefied natural gas (LNG) are significant in some countries and may increase. But the rate of increase is likely to be slow because of the long lead times and the large capital investment required for undersea pipelines, liquefaction, transport, and regasification facilities.

natural gas prices

Moreover, any substantial increase in the world use of natural gas would depend on large exports from countries in the Middle East and North Africa, which are members of OPEC. If, as now appears likely, these countries impose ceilings on their natural gas exports similar to those now being imposed on oil exports, major increases in world natural gas use would not occur, and natural gas prices could tend to closely reflect world oil prices.

unconventional oil and gas sources

In several countries, a vast resource base exists for unconventional oil in the form of oil shale, tar sands, and heavy oil. Canada, for example, already produces about 7 percent of its oil from Alberta tar sand deposits. Coal beds, shales, tight sands, and geopressurized formations may also contain huge amounts of unconventional gas.

Natural Gas

A substantial expansion of unconventional oil or gas production is now being planned for some countries. However, all these unconventional resources are characterized by high capital costs and long lead times for development and their largest contributions are therefore likely to occur after the year 2000.

nuclear uncertainties

Nuclear power already plays a substantial role in electricity generation in some countries. In some regions of the United States and Europe, for example, it supplies up to 30 percent of the total electricity. In several countries it is expected to provide a large share of future needs.

Nuclear reaction

coal

conservation

simple short term measures

conservation decisions

beyond conservation practices

renewable energy sources

geothermal

fuel alcohol

However, nuclear energy has suffered well-publicized setbacks and disappointments in recent years. For example, OECD forecasts of installed capacity in 1985 have been reduced by 60 percent in the past 10 years; projections to the year 2000 have been reduced even more. Although these nuclear forecasts were based on very optimistic projections and the more recent estimates are thought to be more realistic.

There are still, however, political uncertainties in a number of countries about whether or not to expand the use of nuclear power. Until these issues have been resolved and public confidence restored, it is difficult to make confidential predictions about the future contribution that nuclear power will make. Because the choice for new power plants is now almost entirely between coal and nuclear energy, any delay in realizing the currently projected nuclear programs will increase the requirement for coal. This does not mean that coal and nuclear power are necessarily in competition. To the extent that there are clear advantages in establishing a diversified basis for the production of electric power, the relationship between coal and nuclear energy will tend to be complementary rather than competitive.

Aggressive conservation programs now occupy a central place in the energy strategies of many nations. It has been widely suggested that by the year 2000 conservation could hold world energy consumption to a level 20-30 percent below what it would otherwise have reached. Even greater savings are suggested in some projections. Over the next 20 years, conservation may well become one of the world's largest energy "sources."

The first 10-15 percent of energy savings are obtainable by relatively short-term measures such as good housekeeping, better insulation, and improved heating controls. In some sectors and in some countries where energy has been cheap, even larger short-term gains are possible.

To go beyond these immediate measures, however, capital must be invested, and lead times become longer. For instance, replacement of a country's industrial equipment stock may take 20 to 30 years and the turnover of its automobile fleet 7 to 10 years. The fact that many energy conservation decisions must be spread over the populace at large is an additional delaying factor. The achievement of substantial savings therefore tends to be gradual, even with government intervention in the form of tax and financial incentives, as well as regulations governing energy performance standards of buildings and equipment.

The projections made in WOCOL country studies nevertheless assume that high levels of energy conservation will, in fact, be achieved. The assumed savings lead to about a 25 percent reduction by the year 2000 in the amount of energy used in the OECD per units of economic activity (GNP). We strongly support vigorous energy conservation efforts to ensure that the conservation savings achieved are as large as possible; however, we conclude that conservation savings are not of themselves capable of eliminating the world's need for additional energy supplies.

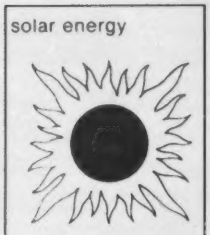
Hydroelectricity is presently the only renewable energy source that makes a substantial contribution to global energy needs. In the future its greatest expansion is likely to be in the developing coutries, some of which have large untapped hydro resources. It can be expected to continue to provide about 5 percent of the world's energy requirements.

Geothermal sources provide useful quantities of energy in some areas today and additional sources are being discovered and developed. The total contribution from geothermal sources will nevertheless inevitably remain geographically limited and relatively small in relation to world energy needs.

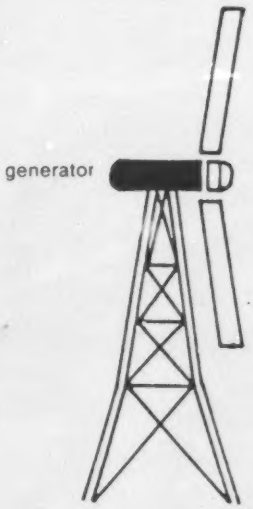
Conversion of biomass to fuel alcohol is also under way in some countries, and it is already making a useful contribution to transport fuel requirements in Brazil.

Solar energy has probably the greatest long-term potential of the renewable resources, but its rate of expansion will be limited by the time required for new technologies to become economic and then penetrate energy markets. Solar collectors for water heating, and in some cases for space heating, are already commercially available. It has been suggested that about 2 percent, or perhaps somewhat more, of the world's primary energy consumption could be supplied in this way by the year 2000. Solar generation of electricity, whether by thermal methods or by photovoltaics, is not yet economic and is therefore unlikely to have a widespread commercial impact during the next 20 years.

Considerable work is also being carried out on many other renewable energy sources including wind, wave, and tidal power; ocean thermal gradients; and various methods of conservation of organic materials. None of these, at present, seems capable of making more than a small contribution to total energy needs by the year 2000, though some may have substantial local impacts.



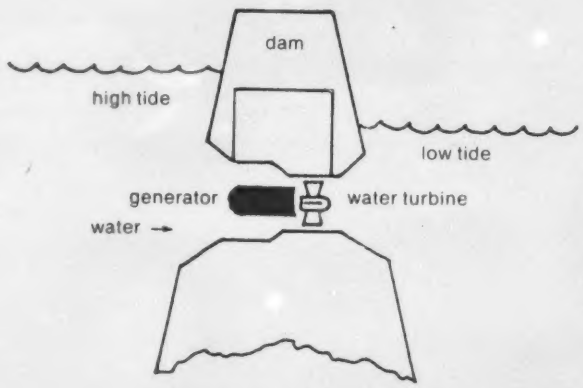
alternative energy



WIND ENERGY

Storage systems for excess energy
- battery
- rapidly spinning flywheel
- water pumped to higher elevation for later release
- compressed air in storage for later driving of turbine

TIDAL POWER



The Need for Coal
Activity #1
Worksheet, Page 1

Name _____

Date _____

Directions: As you read through the various sections of "The Need for Coal," answer these questions.

1. (Page 6) Coal may provide the only way for many of the less developed countries to obtain the fuel needed for what?

2. (Page 8) What resource has provided over 80 percent of the increase in energy use?

3. (Page 8) Why can this resource **not** play an important role in the future use of energy?

4. (Page 8) Why can we **not** assume OPEC production of oil will increase in the future?

5. (Page 9) By examining figure 1-1, how many million barrels per day (mbd) will (OECD) countries use by the year 2000?

6. (Page 10) Why isn't nuclear energy seen as **the** answer to energy problems?

Name _____

Date _____

7. (Page 10) Over the next 20 years, what may well become one of the world's largest energy sources?

8. (Page 11) What energy resource probably has the greatest long-term potential of the renewable resources?

9. (Page 11) What percentage of the world's primary energy consumption could be supplied by solar energy by the year 2000.?

10. What suggestions would you make to the President now that you have read this report?

The Need for Coal
Activity #1
Answer Sheet

Instructor Information...

Directions: As you read through the various sections of "The Need for Coal," answer these questions.

1. (Page 6) Coal may provide the only way for many of the less developed countries to obtain the fuel needed for what?

   Coal may provide the only way for many of the less developed countries to obtain fuel needed for electric power and industrial development, and to reduce their dependence upon oil imports.

2. (Page 8) What resource has provided over 80 percent of the increase in energy use?

   Oil has provided over 80 percent of the increase in energy use.

3. (Page 8) Why can this resource **not** play an important role in the future use of energy?

   The resource cannot play an important role in the future use of energy because oil cannot meet any substantial part of future energy needs.

4. (Page 8) Why can we **not** assume OPEC production of oil will increase in the future?

   We cannot assume OPEC production of oil will increase because political change or revolutions can occur rapidly and unexpectedly as well as other tensions that are unlikely to be resolved soon. Several of these countries want to conserve oil in the ground as security for their future.

5. (Page 9) By examining figure 1-1, how many million barrels per day (mbd) will (OECD) countries use by the year 2000?

   It is expected they will use 22 million barrels per day (mbd).

6. (Page 10) Why isn't nuclear energy seen as **the** answer to energy problems?

   Nuclear energy has suffered public setbacks and disappointments in recent years. There are political uncertainties about whether or not to expand its use.

7. (Page 10) Over the next 20 years, what may well become one of the world's largest energy sources?

   Conservation could become a very large energy source.

8. (Page 11) What energy resource probably has the greatest long-term potential of the renewable resources?

   Solar has a long term potential.

9. (Page 11) What percentage of the world's primary energy consumption could be supplied by solar energy by the year 2000?

   2 percent is predicted.

10. What suggestions would you make to the President now that you have read this report?

    personal opinion

Instructor Information...

Coal

Rationale:

Students may need some understanding of what is known as "coal." This article provides some basic information concerning the types of coal, how it is formed, the various stages in its development, and where coal can be found.

Objectives:

Students will be able to identify the three basic types of coal: lignite, bituminous, and anthracite.

Students will be able to identify the location of the major coal-reserves around the world.

Students will be able to interpret graph information.

Implementation:

Through oral class discussion, have students provide you with as much information as they can on the physical qualities of coal. If students have a good understanding of coal, you can skip to the graphing activity. If students have difficulty in explaining the various stages as to how coal is formed, have them read "Coal". Then have them complete the graph activity.

Debriefing:

Have students check each other's work.

Coal

Activity #2, Page 1

Name_____

Date_____

coal for electricity and coke

Coal is a black or brown rock that can be ignited and burned. As coal burns, it produces energy in the form of heat. The heat from coal can be used to heat buildings and to make or process various products. But the heat is used mainly to produce electricity. Coal-burning power plants supply about half the electricity used in the United States and nearly two-thirds of that used throughout the world. Coal is also used to make **coke**, an essential raw material in the manufacture of iron and steel. Other substances obtained in the coke-making process are used to manufacture such products as drugs, dyes, and fertilizers.

coal's temporary decline

Coal was once the main source of energy in all industrial countries. Coal-burning steam engines provided most of the power in these countries from the early 1800's to the early 1900's. Since the early 1900's, petroleum and natural gas have become the leading sources of energy throughout much of the world. Unlike coal, petroleum can easily be made into gasoline and other fuels needed to run modern transportation equipment. Natural gas is often used in place of coal to provide heat. But the world's supplies of petroleum and natural gas are being used up rapidly. If they continue to be used at the present rate, they may be nearly exhausted within 75 to 100 years. The world's supply of coal can last 300 to 400 years at the present rate of use.

coal's estimated life expectancy

coal lessens the shortage of energy needed

Increased use of coal, especially for producing electricity, could help relieve the growing shortage of gas and oil. However, the use of coal involves certain problems. The burning of coal has been a major cause of air pollution. Methods have been developed to reduce the pollution, but these methods are costly and not yet fully effective. They must be improved before the use of coal can be increased greatly. In addition, some coal lies deep underground and is difficult to mine.

coal's formation

1

Coal is developed from the remainder of plants that died one million to 440 million years ago. For this reason, it is often referred to as a **fossil fuel**. The coal forming plants probably grew in swamps. As the plants died, they gradually formed a thick layer of matter on the swamp floor. Over the years, this matter hardened into a substance called peat. In time, the peat deposits became buried under sand or other mineral matter. As the mineral matter accumulated, some of it turned into such rocks as sandstone and shale. The increasing weight of the rock layers and of the other overlying materials began to change the peat into coal. Coal, sandstone, and other rocks formed from deposited materials are called **sedimentary rocks**.

stages in coal formation

The first stage in the formation of coal produces a dark brown type of coal called **lignite**. Lignite develops from buried peat deposits that have been under great pressure. The pressure results from the weight of the overlying materials and from movements within the earth's crust. As the pressure increases, lignite turns into a harder coal called **subbituminous coal**. Under greater pressure, subbituminous coal turns into a still harder coal called **bituminous coal**. Intense pressure changes bituminous coal into **anthracite**, the hardest of all coals.

anthracites

Anthracites are the oldest coals in most cases, and lignites are the youngest. Some anthracites began to form as long as 440 million years ago. Some lignites developed within the last one million years. The greatest period of coal formation occurred about 300 million years ago, during a time in the earth's history called the **Carboniferous Period**. Swamps covered much of the earth during this period. Tall ferns and other treelike plants grew in the swamps and produced huge amounts of peat-forming matter after they died. Today's plentiful deposits of bituminous coal developed largely from the vast peat deposits formed during the Carboniferous Period. It took about three to seven feet (0.9 to 2.1 meters) of compact plant matter to produce a bed of bituminous coal one foot (0.3 meter) thick.

bituminous coal

peat formation

Plant materials are still accumulating in such coal-forming environments as the Everglades, the huge swamplands of southern Florida. Under the proper conditions, these materials could eventually develop into peat and then, over hundreds of thousands of years, into various kinds of coal.

Name _____

Date _____

seams of coal

Coal beds are also called **coal seams or coal veins**. Present day seams range in thickness from less than one inch (2.5 centimeters) to 440 feet (120 meters) or more. The thickest seams are subbituminous coals and lignites. Many coal deposits consist of two or more seams separated by layers of rocks. These formations were produced by new coal-forming swamps developing over buried ones. Each new swamp became buried and developed into a separate seam of coal.

beds of coal

Some coal beds lie nearly parallel to the earth's surface. Other beds have been tilted by earth movements and lie at an angle to the surface. Most of the deepest beds consist of anthracites or bituminous coals. In many cases, earth movements have uplifted deep anthracite and bituminous beds to a position nearer the surface. Such movements also account for coal seams in hills and mountains.

where coal is found

Coal is found on every continent. Deposits occur as far north as the Arctic and as far south as Antarctica. Some coal deposits occur off ocean coastlines. However, deep underwater deposits have little value at this time because they are difficult to mine.

Coal deposits that can be mined profitably are called **coal reserves**. In most cases, a coal seam must be at least 24 inches (61 centimeters) thick for mining engineers to classify it as a reserve. Some long-range estimates of coal reserves include beds 12 to 24 inches (30 to 61 centimeters) thick. But such thin beds would probably be mined only after more productive deposits were exhausted. Most estimates of coal reserves include only tested deposits. The reserves may actually be somewhat larger or smaller than the estimates.

To estimate coal reserves, mining engineers drill into the ground in suspected coal-bearing areas. A drill brings up samples of the rock formations in the order in which they occur. The depth and thickness of a coal seam can thus be estimated. By taking a number of such samples, engineers can estimate the extent of a particular deposit. A large area of tested reserves is called a **coal field**.

world coal reserves

Estimates of world coal reserves range from about 650 billion short tons (590 billion metric tons) to over 1,500 billion short tons (1,360 billion metric tons). The lower figure includes only the reserves that can be mined economically. The higher figure includes deposits that cannot now be mined profitably. The United States has 30 to 35 percent of the world's coal reserves. Russia has about 25 percent, and China has about 15 percent. Most of the remaining reserves are in Australia, Canada, Great Britain, India, Poland, South Africa, and West Germany.

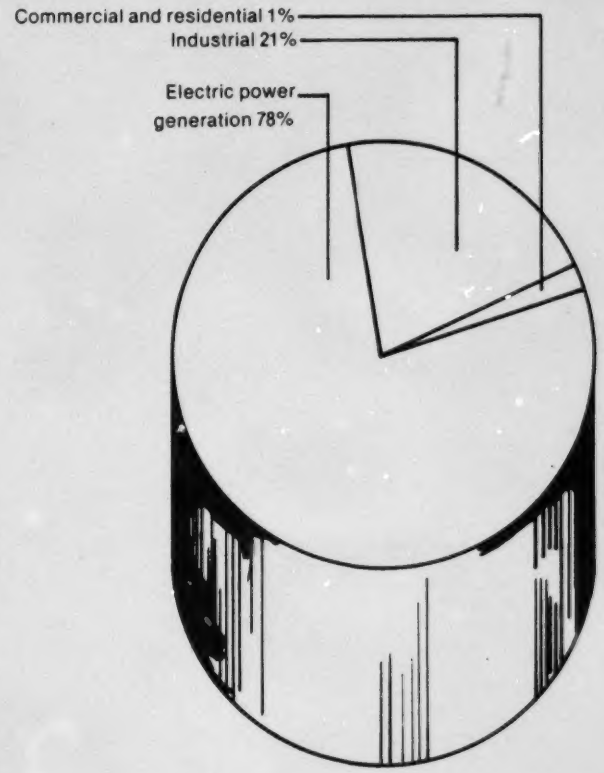
location of U.S. and Canadian reserves

About half of all U.S. coal reserves lie in the eastern half of the nation, from the Appalachian Highlands to the eastern edge of the Great Plains. The rest are in the western part of the country, especially the Rocky Mountain States, the northern Great Plains, and Alaska. The eastern reserves include nearly all the nation's anthracite deposits and more than three-fourths of its bituminous deposits. The western reserves include almost all the subbituminous and lignite in the United States.

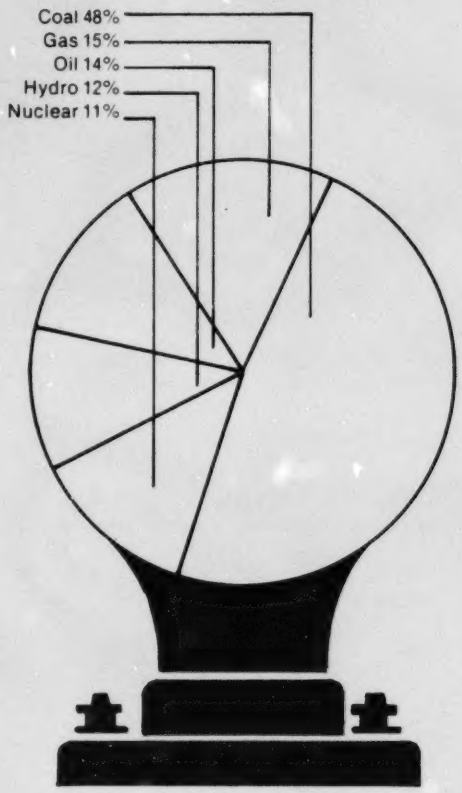
Canada Bituminous Deposits

Canada's coal reserves consist chiefly of bituminous coal. The nation also has large fields of subbituminous coal and lignite. But the deposits are much thinner than the bituminous deposits. More than 95 percent of Canada's reserves are in the western provinces—British Columbia, Alberta and Saskatchewan.

How coal is used by economic sector



Primary Sources of Electric Energy What We Use To Make It



Name_____

Date_____

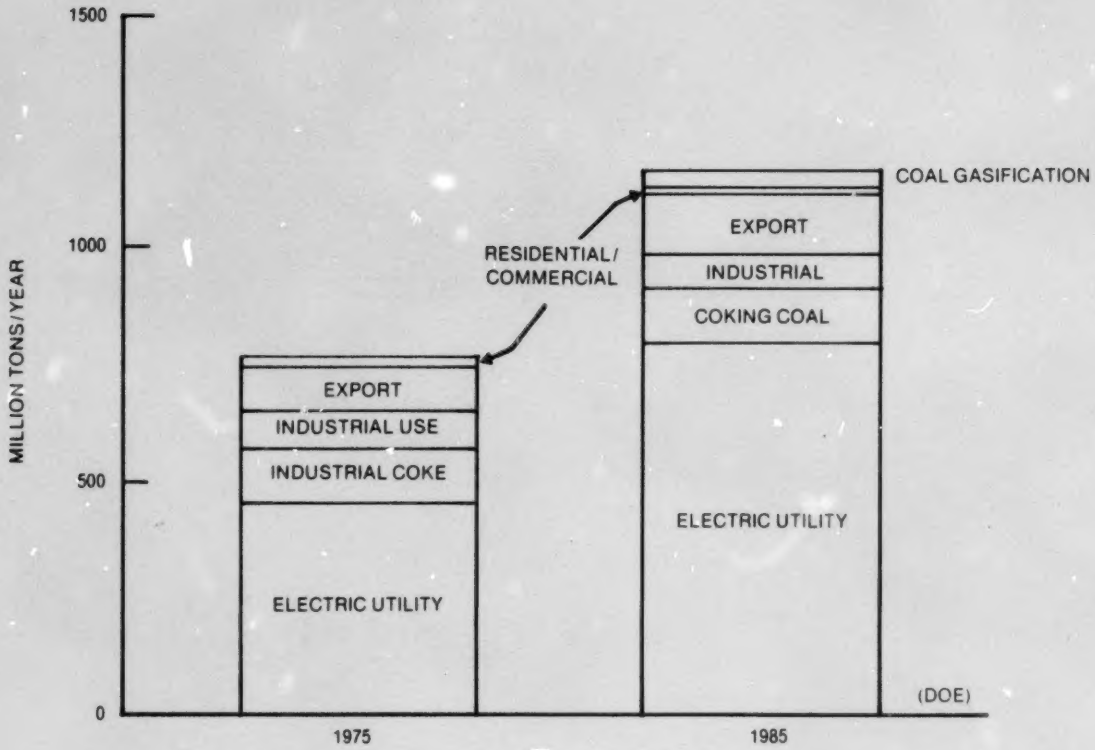


Figure 11-9. Demand For Coal By Use, 1975 and 1985

Directions: Answer the questions using the information from the above graph.

1. In 1985, most coal will be used for what purposes?

_____

2. What is the total amount of coal to be used in 1985?

_____

3. What new use will coal be used for in 1985?

_____

Name_____

Date_____

4. How much coal was used in 1975?

_____

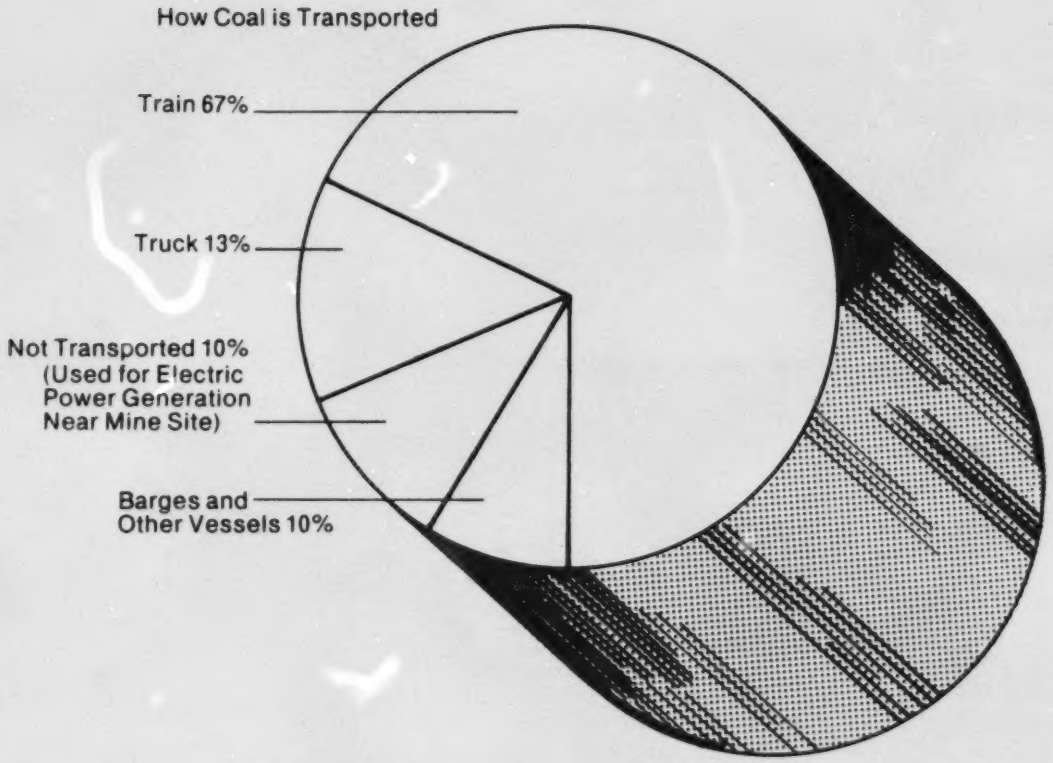
5. If you were to predict the amount of coal needed for 1995, what would it be?

_____

How did you decide on this amount?

_____

_____



Instructor Information...

A Laboratory Simulation of Coal Formation

Concept

How coal is formed

Questions

—What gases escape the tube as leaves and twigs are heated?
—What element remains after the plant material is burned?

Objectives

—The student will be able to identify gases escaping from the heated tube.
—The student will be able to identify the type of material remaining after burning it.

Process Skills

Analyzing, experimenting, observing, testing.

Time

Twenty to thirty (20-30) minutes for the actual experiment

Background

This experiment attempts to show students that certain gases escape when leaves and twigs are burned. Also, they will examine the material left over from the burning and attempt to identify it.

Materials

—heat proof test tube
—one-hole stopper to fit the test tube
—a small amount of shredded leaves and bits of broken twigs
—access to a flame.

Procedure/Sequence

1. Gather the shredded leaves and bits of broken twigs and pack the plant material into the test tube.
2. Fill the test tube three-fourths full and put in the stopper.
3. If the stopper is unavailable, plug the end with clay and run a wooden match through the plug to make a hole.
4. Heat the test tube gently by passing it in and out of the flame.

Instructor Information...

Questions

1. As the test tube begins to heat up, describe what is happening.
2. Do you see a gas escaping? Think about what you read concerning the formation of coal. What could the name of the gas or gases be?
3. What color is the remaining material?
4. Is there a flame in the test tube? Why not?
5. Keep heating the test tube. What color is the material when no further changes occur?
6. Let the test tube cool and shake out the black plant material to examine. This substance is made of the same black element that composes coal. What is this element?

Answers to Questions

1. Depends on student observations.
2. The gases could be methane and sulfur dioxide.
3. Depends on student observations.
4. There is no flame in the test tube because there is little or no oxygen in the test tube.
5. Depends on student observations.
6. The remaining element is carbon.

A Laboratory Simulation of Coal Formation
Activity #3
Worksheet

Name _____

Date _____

Directions: After completing the experiment, "A Laboratory Simulation of Coal Formation," answer these questions.

1. As the test tube begins to heat up, describe what is happening.

2. Do you see a gas escaping? _____ Think about what you read concerning the formation of coal. What could the name of the gas or gases be?

3. What color is the remaining material?

4. Is there a flame in the test tube? _____ Why or why not?

5. Keep heating the test tube. What color is the material when no further changes occur?

6. Let the test tube cool and shake out the black plant material to examine. This substance is made of the same black element that composes coal. What is this element?

Instructor Information...

Chemical Composition of Coal

Rationale:

Coal contains a high percentage of carbon. It burns and releases tremendous amounts of energy. Students can obtain a better picture of the information by graphing it. In this activity, students will read about the chemical composition of coal and then determine how to graph this information.

Objectives:

Students will be able to identify the terms "chemical composition" and "fuel".

Students will be able to design a horizontal bar graph using one of the chemical elements provided.

Implementation:

Hand out to students, "Chemical Composition of Coal." After this is read and discussed, explain the importance of providing different ways of presenting your information. Give students examples of the type of graph you want them to develop (several are provided).

Debriefing:

As students begin to design their graphs, make sure they include the minimum elements of a good graph. These are: title, a label for both axes, and correctly graphing the information. Students could do additional graphs such as vertical and pie graphs.

Name_____

Date_____

Chemical Composition of Coal

kindling temperatures

carbon

Coal, like all compounds has certain properties. By chemical properties we mean the ways of reacting while in the presence of other chemicals or heat. We will be exploring the chemical properties of coal today.

Coal is considered to be a fuel because it will burn and release tremendous amounts of energy. Fuels have different kindling temperatures. A kindling temperature is the temperature at which the fuel will start to burn. Some fuels, such as wood, have low kindling temperatures. Wood products can be made to burn by using the heat from a single match. Coal has a higher kindling temperature than wood. A single match is not enough to set fire to an ordinary size piece of coal. Coal fires are usually started by hotter kindling wood fires.

Coal is made of high concentrations of carbon. The amount in the coal determines its rank.

Chemical Composition of Coal

Activity #4
Worksheet

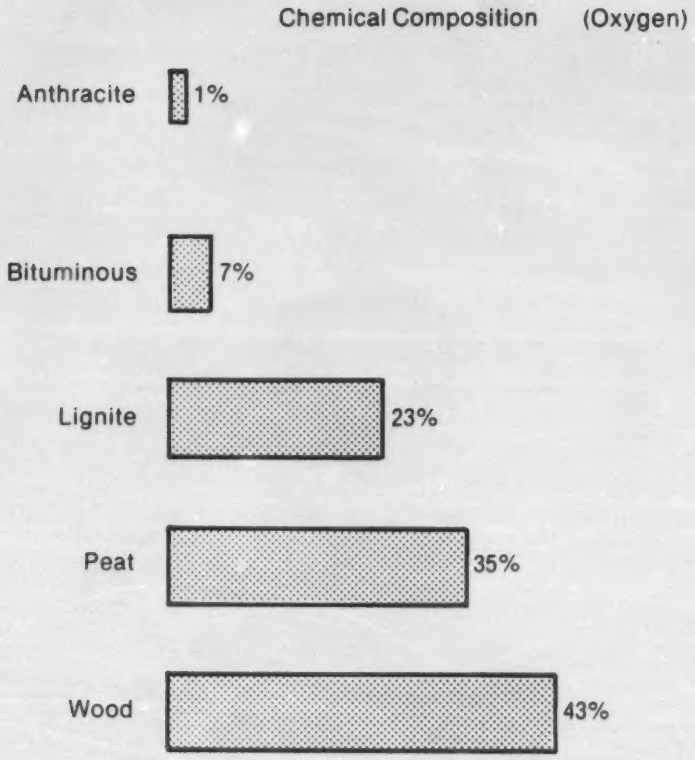
Name_____

Date_____

Directions: Use any of the four chemical compositions to design a horizontal bar graph.

	Carbon	Oxygen	Hydrogen	Nitrogen
	%	%	%	%
Wood	50	43	6	1
Peat	57	35	7	1
Lignite	70	23	6	1
Bituminous	85	7	6	2
Anthracite	94	1	4	1

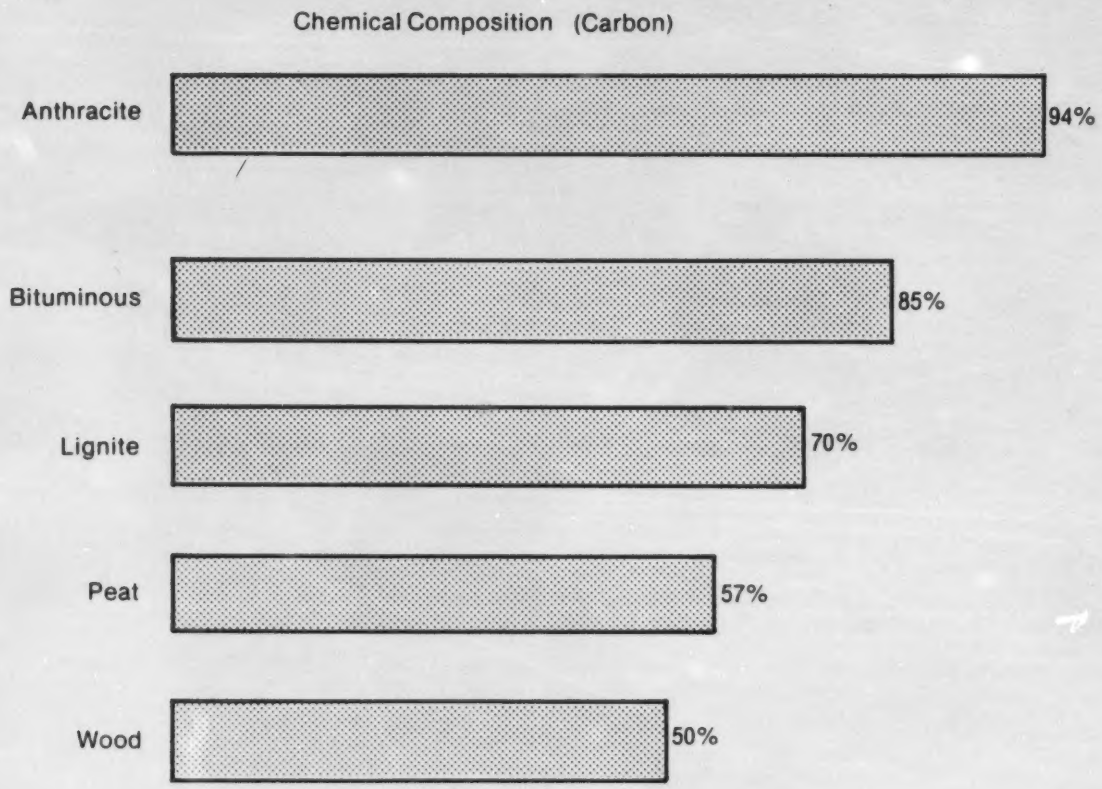
Instructor Information...



Things to include in the graphing:

1) Title of graph
2) Horizontal labels
3) Vertical labels
4) Graph the information

Instructor Information...

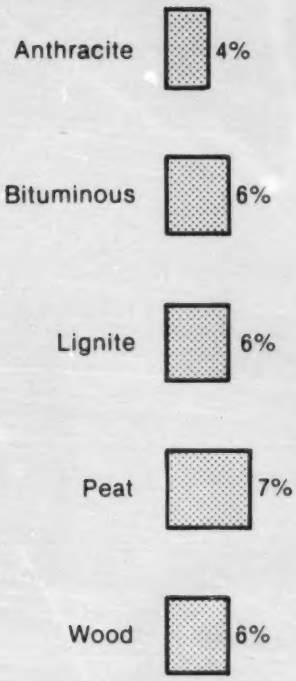


Things to include in the graphing:

1) Title of graph
2) Horizontal labels
3) Vertical labels
4) Graph the information

Instructor Information...

Chemical Composition (Hydrogen)

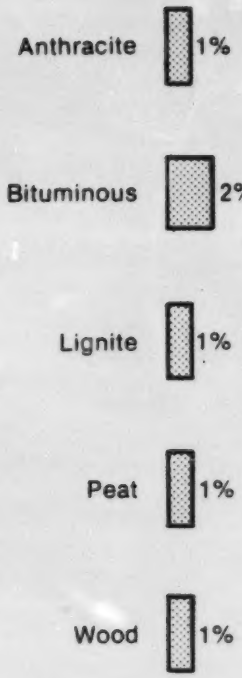


Things to include in the graphing:

1) Title of graph
2) Horizontal labels
3) Vertical labels
4) Graph the information

Instructor Information...

Chemical Composition (Nitrogen)



Things to include in the graphing:

1) Title of graph
2) Horizontal labels
3) Vertical labels
4) Graph the information

U.S. Coal Desposits
Activity #1
Worksheet

Name _____

Date _____

Directions: Using the map "U.S. Coal Deposits," answer the following questions by circling the correct letter.

1. Most bituminous coal deposits are located in the a) eastern United States, b) western United States.
2. The largest deposits of lignite are located in the a) southern, b) northern, c) eastern, d) western part of the United States.
3. What type of coal is located in North Dakota?
   a) anthracite, b) bituminous, c) subbituminous, d) lignite.
4. Nebraska has some deposits of a) lignite, b) subbituminous, c) bituminous, d) anthracite coal located in the eastern part of the state.
5. Wyoming has many deposits of a) lignite, b) subbituminous, c) bituminous, d) anthracite.
6. What is the least abundant supply of coal available in the United States? a) bituminous, b) subbituminous, c) lignite, d) anthracite coal.
7. What kind of coal is located in the Appalachian Mountains? a) bituminous, b) subbituminous, c) lignite, d) anthracite.
8. Alaska has many deposits of a) anthracite, b) lignite, c) bituminous, d) subbituminous
9. What type of coal is mined in Maine? a) lignite, b) none, c) bituminous, d) anthracite.

Instructor Information...

Directions: Using the map "U.S. Coal Deposits," answer the following questions by circling the correct letter.

1. Most bituminous coal deposits are located in the (a) eastern United States, b) western United States.
2. The largest deposits of lignite are located in the a) southern, (b) northern, c) eastern, d) western part of the United States.
3. What type of coal is located in North Dakota?
   a) anthracite, b) bituminous, c) subbituminous, (d) lignite.
4. Nebraska has some deposits of a) lignite, b) subbituminous, (c) bituminous, d) anthracite coal located in the eastern part of the state.
5. Wyoming has many deposits of a) lignite, (b) subbituminous, c) bituminous, d) anthracite.
6. What is the least abundant supply of coal available in the United States? a) bituminous, b) subbituminous, c) lignite, (d) anthracite coal.
7. What kind of coal is located in the Appalachian Mountains? (a) bituminous, b) subbituminous, c) lignite, d) anthracite.
8. Alaska has many deposits of a) anthracite, b) lignite, c) bituminous, (d) subbituminous
9. What type of coal is mined in Maine? a) lignite, (b) none, c) bituminous, d) anthracite.

Instructor Information...

"How Coal is Mined"

Rationale:

There are basically two types of mining: surface and underground. This article explains both methods and provides specific details of the mining process. For students who are very much interested in the mining of coal, this is an informative start.

Objectives:

Students will be able to read "How Coal is Mined".

Students will be able to discuss the differences between surface mines and underground mines.

Students will be able to design and complete a word search.

Implementation:

Hand out the reading entitled "How Coal is Mined." Have students read the article, then discuss major differences between surface and underground mining. For a change of pace, hand out the blank squares page and have students select key words from the reading and write them in the blanks. They should list the words at the bottom of the page so that when they exchange their word search with another student, they will know what words to look for in the word search. Once they have 15-20 words written in the word search, they should then fill in the rest of the the squares with letters from the alphabet. Once they complete their word search, exchange it with another student and circle the words of the other student's word search.

Debriefing:

After reading the articles, have students explain the differences between the two types of mining. Students should also be able to explain such terms as strip mining, reclamation, area mining, contour mining, shaft, slope, and drift mines.

Students can then design the word search and exchange them with others.

Name _____

Date _____

surface mining

production from surface mining

auger mining

reclaiming the land

producing coal

removing the coal

area the contour mining

How Coal is Mined

Coal mines can be divided into two main groups: (1) surface mines and (2) underground mines. In most cases, surface mining involves stripping away the soil and rock that lie over a coal deposit. This material is known as **overburden**. After the overburden has been removed, the coal can easily be dug up and hauled away. Underground mining involves digging tunnels into a coal deposit. Miners must go into the tunnels to remove the coal.

Surface mining is usually limited to coal deposits within 100 to 200 feet (30 to 61 meters) of the earth's surface. The more overburden that must be removed, the more difficult and costly surface mining becomes. Most coal deposits deeper than 200 feet are mined underground. Surface mines produce about 60 percent of the coal mined in the United States. Underground mines produce the rest.

Nearly all surface mining is **strip mining**—first stripping away the overburden. Many coal seams are exposed on the sides of hills or mountains. In some cases, these seams are mined from the surface without removing any overburden. Miners use machines called **augers** to dig out the coal. This method of surface mining is known as **auger mining**.

Strip Mining depends on powerful machines that dig up the overburden and pile it out of the line of work. The dug-up overburden is called **spoils**. In time, a strip mine and its spoils may cover an enormous area. The digging up of vast areas of land has caused serious environmental problems in the past. As a result, the United States government now requires that all new strip-mined land must be **reclaimed**—that is, returned as closely as possible to its original condition. Strip mining thus involves methods of (1) mining the coal and (2) reclaiming the land.

Mining the Coal. Most strip mines follow the same basic steps to produce coal. First, bulldozers clear and level the mining area. Many small holes are then drilled through the overburden to the coal bed. Each hole is loaded with explosives. The explosives are set off, shattering the rock in the overburden. Giant power shovels or other earthmoving machines then start to clear away the soil and broken rock. Some of these earthmovers are as tall as a 20-story building and can remove more than 3,500 short tons (3,180 metric tons) of overburden per hour. After a fairly large area of coal is exposed, smaller power shovels or other coal-digging machines scoop up the coal and load it into trucks. The trucks carry the coal from the mine.

Although most strip mines follow the same basic steps, strip-mining methods vary according to whether the land is flat or hilly. Strip mining can thus be classed as either (1) area mining or (2) contour mining. Area mining is practiced where the land is relatively level. Contour mining is practiced in hilly or mountainous country. It involves mining on the **contour**—that is around slopes.

cuts and spoil banks

In area mining, an earthmover digs up all the broken overburden from a long, narrow strip of land along the edge of the coal field. The resulting deep ditch is referred to as a **cut**. As the earthmover digs the cut, it piles the spoils along the side of the cut that is away from the mining area. The piled spoils form a ridge called a **spoil bank**. After the cut is completed, the coal is dug, loaded into trucks, and hauled away. The earthmover then digs an identical cut alongside the first one. It piles the spoils from this cut into the first cut. This process is repeated over and over across the width of the field until all the coal has been mined. The spoil banks form a series of long, parallel ridges that can later be leveled.

Area mining is impractical where coal seams are embedded in hills. If a seam lies near the top of a hill, an earthmover may simply remove the hilltop and so expose the coal. If a seam lies near the base of a hill, it must be mined on the contour.

contour mining

In contour mining, an eathmover removes the shattered overburden immediately above the point where a seam **outcrops** (is exposed) all around a hill. The resulting cut forms a wide ledge on the hillside. The spoils may be stored temporarily on the hillside or used to fill the cuts. After the exposed coal has been mined and hauled away, the earthmover may advance up the slope and dig another cut immediately above the first one. However, the depth of the overburden increases sharply with the rise of the slope. After the first or second cut, the overburden may be too great for a coal company to remove profitably. But if the seam is thick enough, a company may dig an underground mine to remove the rest of the coal.

reclaiming the land

The chief environmental problems that strip mining can cause result from burying the fertile soil; under piles of rock. The rocks tend to give off acids when exposed to moisture. Rainwater runs down the bare slopes, carrying acids and mud with it. The runoff from the slopes may wash away fertile soil in surrounding areas and pollute streams and rivers with acids and mud.

reducing slopes and leveling spoils

The first step in reclaiming strip-mined land is to reduce the steep slopes formed by the spoils. The spoil banks created by area mining can be leveled by bulldozing. The spoils from contour mining can be used to fill in the cuts on hillsides. As much topsoil as possible should then be returned to its original position so that the area can be replanted.

restoring the land

Mining companies have reclaimed much strip-mined land, which has been turned into farms and recreation areas in many cases. But much land has not been reclaimed. In 1977, the U.S. Congress passed a law requiring miners to reclaim all the land they use from strip mining after 1978. In every case, the mine owners must restore the land as nearly as possible to its original condition.

auger mining

A coal auger is a machine shaped like an enormous corkscrew. It bores into the side of a coal outcrop on a slope and twists out the coal in chunks. Contour mines often use augers when the overburden in a slope is too great to remove. An auger can penetrate the outcrop and recover coal that could not otherwise be mined. Some augers can bore 200 feet (61 meters) or more into a hillside.

problem of auger mining

A few companies specialize in auger mining, chiefly to mine outcrops of high-quality coal that cannot be mined economically by other methods. However, auger mining can recover only a small portion of the coal in a seam. The method is most efficient when used in combination with contour mining.

underground mining

Underground mining is more hazardous than surface mining. The miners may be injured or killed by cave-ins, falling rocks, accidental explosions, and poisonous gases. To prevent such disasters, every step in underground coal mining must be designed to safeguard the workers.

Underground mining requires more human labor than does surface mining. But even so, underground mines are highly mechanized. Machines do all the digging, loading, and hauling in nearly all the mines. Nonmechanized mines produce only about 1 percent of the coal mined underground in the United States.

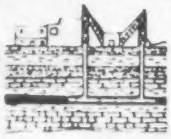
the process of underground mining

In most cases, miners begin an underground mine by digging two access passages from the surface to the coal bed. One passage will serve as an entrance and exit for the miners and their equipment. The other passage will be used to haul out the coal. Both passages will also serve to circulate air in and out of the mine. As the mining progresses, the workers dig tunnels from the access passages into the coal seam.

types of underground mines

Underground mines can be divided into three main groups according to the angle at which the access passages are dug into the ground. The three groups are (1) shaft mines, (2) slope mines, and (3) drift mines. Some mines have two or all three types of passages.

a shaft mine



In a shaft mine, the access passages run straight down from the surface to the coal seam. The entrance and exit shaft must have a hoist. Most extremely deep mines are shaft mines. In a slope mine, the access passages are dug on a slant. The passages may follow a slanting seam or slant down through a hillside to reach a seam under the hill. Drift mines are used to mine seams of coal that are embedded in hills or mountains. The access passages are dug directly into the side of a seam where it outcrops on a slope. They thus parallel the ground.

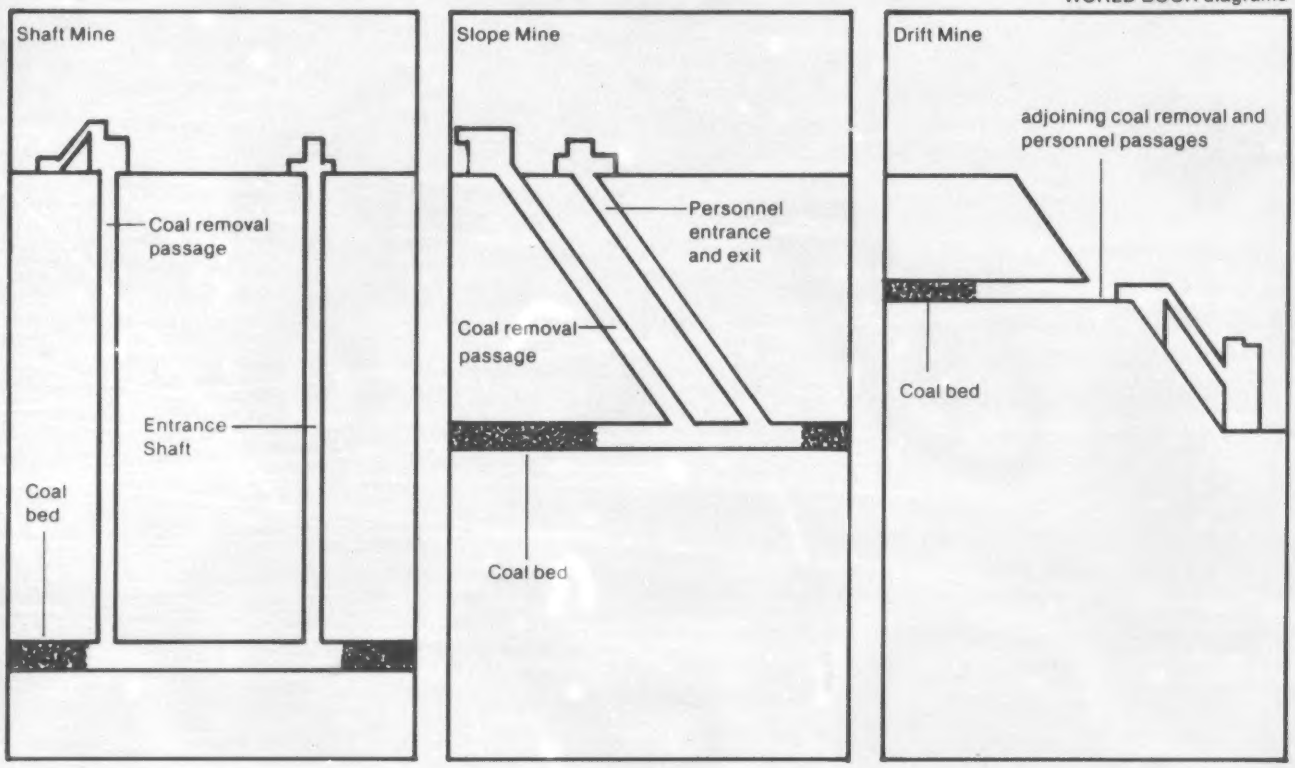
ways to mine

Two main systems of underground mining are used: (1) the room-and-pillar system and (2) the long-wall system. Each system has its own set of mining techniques. Either system may be used in a shaft, slope, or drift mine. The room-and-pillar system is by far the more common system of underground mining in the United States. The long-wall system is more widely used elsewhere, especially in European countries.

Kinds of Underground Mines

There are three main kinds of underground mines: (1) shaft mines, (2) slope mines, and (3) drift mines. In a shaft mine, the entrance and exit passages are vertical. In a slope mine, they are dug on a slant. In a drift mine, the passages are dug into the side of a coal bed exposed on a slope.

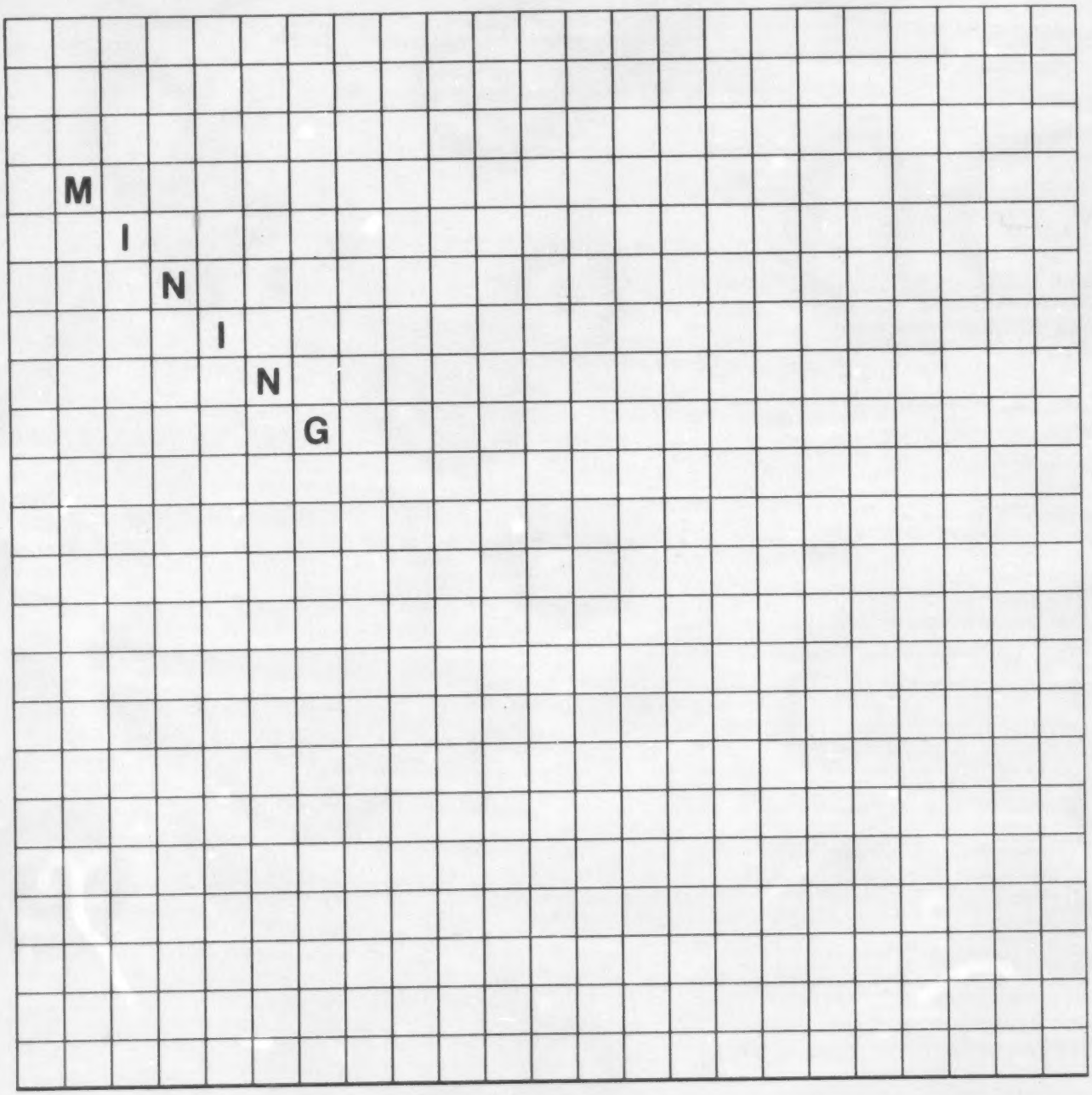
WORLD BOOK diagrams



How Coal is Mined
Activity #6
Wordsearch

Name _____

Date _____



Words to look for in the wordsearch

Instructor Information...

Collecting Methane Gas

Concept

Many mines have concentrations of methane gas.

Question

—Why is mining a dangerous occupation?

Objectives

—The student will be able to trap methane gas.
—The student will be able to research methane gas effects.

Process Skills

Analyzing, experimenting, hypothesizing, observing, testing.

Time

Two days

Background

The mining of coal is a hazardous occupation because many mines have concentrations of methane gas. Even though this experiment develops only a small amount of methane, you need to caution students as to care and safety in attempting this experiment.

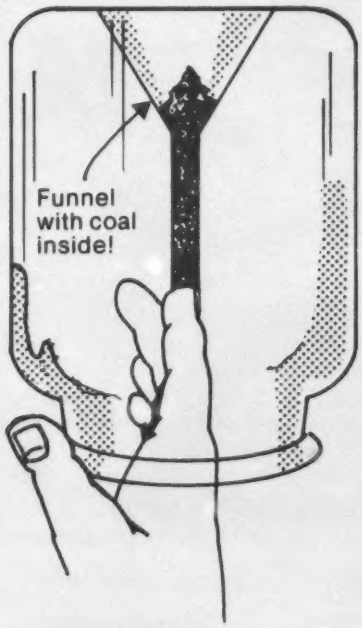
Materials

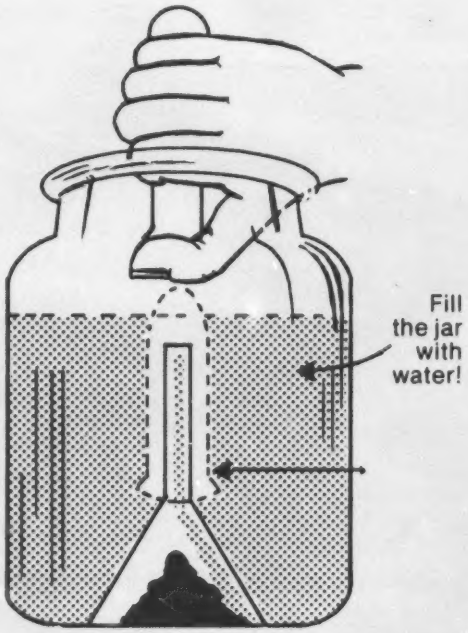
—soft or bituminous coal (hammered to a powder)
—funnel
—quart jar
—water
—test tube
—match
—rubber band

Instructor Information...

Procedure/Sequence

1. Gather the above mentioned materials.
2. Put the coal in the wide end of the funnel and your finger in the narrow end. Place the jar over the funnel.
3. Turn the jar upright and fill with water. Water will get into the funnel but that is fine.
4. Fill the test tube with water and place it over the funnel. **Do Not Let Air In!!!**
5. Mark the test tube at the water line with a rubber band.
6. Set the jar aside for two days.
7. In two days, remove the test tube (keeping the open end down. This will trap the methane in the top of the tube).
8. Keeping your thumb over the open top of the test tube, turn it right side up.
9. Light up a match and place if near the open top of the test tube. As the air escapes, the methane will also escape and there will be a "pop".
10. Students should then complete their worksheets.





Name _____

Date _____

Collecting Methane Gas

Directions: After observing the experiment, answer the following:

1. What observations did you make?

2. What conclusions can be drawn?

Name _____

Date _____

3. Why is mining a dangerous occupation?

4. Extra Assignment!

   Research any mining disasters to find out what the cause was for the explosion.

Instructor Information...

Coal: Always a Bridesmaid

Rationale:

America has been called the "Saudi Arabia of Coal." It contains vast amounts of coal, but there are various considerations to be weighed in using coal as a fuel source. At present there are problems of production, burning of coal, and effects on the environment. This activity provides students with an explanation of such terms as "over capacity," the "greenhouse effect," and "environmental problems."

Objectives:

Students will be able to identify problems associated with the use of coal.

Students will be able to explain "overcapacity" and "greenhouse effect."

Implementation:

Hand out the reading entitled "Coal: Always a Bridesmaid," and read. After discussing such items as "overcapacity" and "greenhouse effect," hand out the worksheet by the same title. Students should then be able to answer these five questions (you may choose to use the questions as part of a follow-up quiz).

Debriefing:

As mentioned above, the worksheet may be used as a follow-up quiz. The questions could also be used in group discussion with an appointed recorder writing out the answers for the group.

Name _____

Date _____

Coal: Always a Bridesmaid

the "Saudi Arabia of coal"

During the Arab oil embargo, Americans sized up the nation's enormous coal supply and looked ahead to another coal boom and escape from the OPEC noose. Six years later, thousands of miners are still unemployed here in the self-proclaimed "Saudi Arabia of Coal," and coal executives are pointing out wearily that their product is "demand-constrained."

a slow growing market

They are not explaining so much as complaining, because the grievance reflects one of the most grinding frustrations of the entrepreneur: He sees that he has a plainly needed product that ought by now to be in brisk demand. But he can't sell it. Granted, some 700 million tons of American coal will be burned in 1979, with utilities using coal to generate nearly half their electricity. Yet consumption has not increased quickly enough to produce a very significant gain in coal use, or more importantly, to ease the nation's addiction to oil.

overcapacity

The coal industry suffers from what economists call overcapacity: more ability to produce than it has buyers to consume. Even with oil and the atom losing ground as future sources of electricity, an annual growth in coal demand of only 5 to 7 percent was forecast recently by Carl Bagge, president of the National Coal Association (NCA).

ups and downs of the coal industry

Such frustration is nothing new. Coal mining has a long and bitter history of marginal profits, roller coaster booms and depressions, enormous displacement of men by machines, and—in the environmental area that began in the 1960's—enough social disapproval and new regulatory legislation to drive its executives up the board room wall.

a "dirty" business

The number one reason is that coal is dirty. It is dirty to mine—with one of the worst health and safety records of any basic American industry. Nor has the industry won accolades for its strip mining, which, in many parts of the country, has been reckless. The industry is having what Robert H. Quenon, NCA's chairman, calls "some success" in curbing both mine injuries and deaths and strip mining abuses under tough new federal laws, passed over bitter resistance in the 1970s.

"acid" rain

But coal is also dirty to burn, filling the atmosphere with chemical pollutants that have effects far and near. Often, for example, there is a fallout of acid rainfall, mixed in an innocent-looking sky, that kills fish, sours lakes, and stunts vegetation hundreds of miles from smokestackers pouring out tons of sulfur oxides liberated by burning coal. In upper New York State and in Canada, coal burned in the Ohio River Valley sterilizes remote, wilderness lakes. Sweden has an acid rain fallout from Britain.

greenhouse effect

And now there is growing concern about an even more exotic atmospheric phenomenon: the so-called "greenhouse effect." Carbon dioxide, a product of all combustion, is slowly increasing in the Earth's atmosphere. Carbon dioxide lets in the infrared, or heat rays of sunlight but holds in—like a greenhouse—the radiant heat reflected from the surface.

affects on the weather

Some scientists believe that if fossil fuel combustion continues to increase—and under present plans most of the added combustion would be coal—the Earth's temperature might rise enough to change the weather. This could effect agriculture dramatically and melt enough of the polar ice caps to raise coastal sea levels. While other scientists consider this fear exaggerated, nobody so far has a good understanding of this highly complex matter.

removing pollutants

Sulfur and other pollutants can be captured in flue gas or removed from the coal before burning, but at a cost for "scrubbing" equipment that the electric industry has been reluctant to pay. There is no known technology, however, for controlling a carbon dioxide buildup. It is an environmental problem which began attracting public attention only recently.

Name_____

Date_____

Thus the shift to coal, which would last 80 to 200, or even 400 years at an all-out level of production, is likely to continue under some constraints. A decade of environmental law, much of which is controlled and enforced by state and local governments, would have to be rolled back to clear the way for large-scale exploitation of coal, and that is an unlikely event.

shifting to coal

Many outside the industry believe that this administrative and political reality, more than the huge cost of the projected building program, is also likely to limit the scope of a wholly new sector of the energy business—the manufacture of synthetic fuels from coal.

synthetic fuels from coal

For example, scanning 159 counties in 22 states, from Alabama to Wyoming, for coal field areas where there is enough fuel and water to locate a $2 billion synfuel refinery, the Department of Energy (DOE) was able to pinpoint in a preliminary survey, only 41 counties in eight states where one such plant could be operated without violating current air and water quality standards or other environmental rules. The response of local residents varies. Some fear a boomtown nightmare, while others welcome the jobs and commerce.

locating plants

Another problem for the coal industry is the product's rising cost, which is due partly to the safety, health and environmental laws. According to DOE, the price of coal has more than tripled in the past ten years—and has nearly doubled in the last four. This is a reality that coal's number one customer, the utilities, cannot ignore.

coal's rising cost

There are other debates as well. Should coal-slurry pipelines be built to compete with the railroads? Should the government champion strip mining or deep mining? Which is more desirable: high-Btu eastern coal or low-sulfur western coal?

questions to be answered

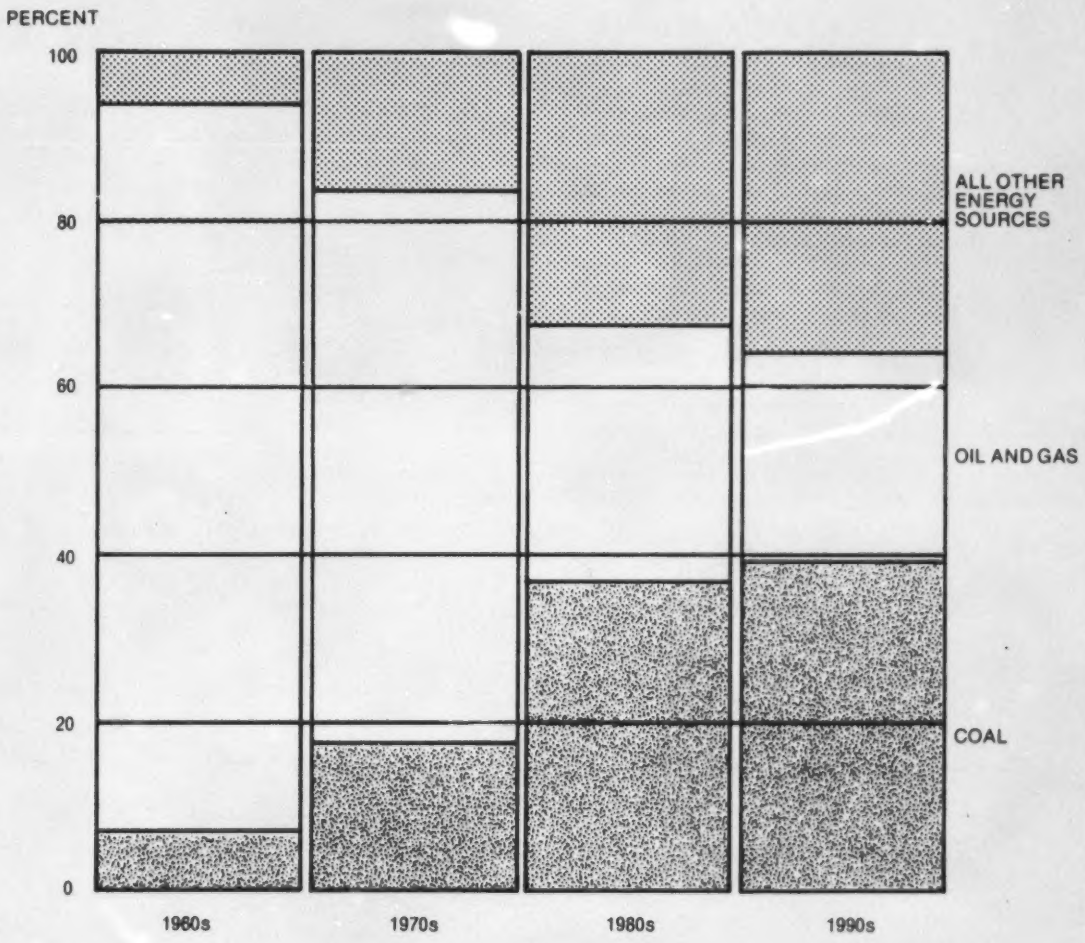
In the short run, coal seems assured of steady, but not spectacular expansion. Unpredicted consumer conservation—and higher rates of electricity—have reduced the annual rise in electric power consumption to nearly half the 7 to 8 percent-a-year gain customary until only a few years ago. But hundreds of new power plants will have been built by 1990, and most of them will be required by law to run on coal.

coal as a bridge

the future

What is less certain, for reasons that may become clearer through the smog of controversy surrounding every facet of energy policy in the coming years, is the consummation of the Arabian Nights dream of America as the "Saudi Arabia of Coal," even in the long range future.

Percentage of growth in world energy supply



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Coal: Always a Bridesmaid
Activity #8,
Worksheet

Name _____

Date _____

Directions: After reading the article "Coal: Always a Bridesmaid," answer the following:

1. According to this article, the coal industry suffers from what economists call overcapacity. What do they mean by this?

2. Identify two reasons coal has received so much social disapproval.

3. Explain the phenomenon known as the "greenhouse effect."

4. What effects would the increase in the earth's temperature have on such things as weather, agriculture, sea levels?

5. Why don't we build more synfuel refineries?

Instructor Information...

Coal: Always a Bridesmaid

Directions: After reading the article "Coal: Always a Bridesmaid," answer the following:

1. According to this article, the coal industry suffers from what economists call overcapacity. What do they mean by this?

   Over capacity means the coal industry has more ability to produce than it has buyers to consume.

2. Identify two reasons coal has received so much social disapproval.

   Coal has received so much disapproval because 1) it is dirty to mine, with a poor health and safety record, and 2) strip mining has been reckless.

3. Explain the phenomenon known as the "greenhouse effect."

   This is the process by which carbon dioxide is increasing in the earth's atmosphere. This increase is brought about by the combustion of coal. The carbon dioxide lets in the infrared or heat rays of the sunlight but holds in—like a greenhouse—the radiant heat reflected from the surface.

4. What effects would the increase in the earth's temperature have on such things as weather, agriculture, sea levels?

   The increase in the earth's temperature would change the weather which could affect agriculture dramatically and melt enough of the polar ice caps to raise coastal sea levels.

5. Why don't we build more synfuel refineries?

   At present, synfuel plants violate most current air and water quality standards or other environmental rules.

Instructor Information...

Coal: Abundant Resource, Abundant Problems

Rationale:

The United States has a rich supply of coal, at least a third of the total world's reserves. With this abundance comes potential problems in mining it. It must be economically feasible to be mined and yet safe enough to be recovered for us to use. This article contains information about the enormous amount of coal available.

Objectives:

Students will be able to read "Coal: Abundant Resource, Abundant Problems" and discuss the advantages and disadvantages of using coal.

Implementation:

Hand out "Coal: Abundant Resource, Abundant Problems." Have students read individually or as a class. Discuss the reading.

Debriefing:

The following questions may be useful in the discussion:

1. What three countries own nearly two-thirds of all known coal reserves?
2. What is misleading about the fact these reserves would last the world **more than 200 years at present rate**?
3. What are some problems in the mining of coal?
4. For what purpose is most coal used?
5. What kinds of damage can coal do to human lungs?

Name_____

Date_____

potential of coal

big producers

hidden reserves

the rise of coal

the costs involved

the return of coal

Coal: Abundant Resource, Abundant Problems

A recent study described coal as a "bridge to the future." As the most plentiful fossil fuel in the world, coal has the potential for filling a growing proportion of the demand for energy.

Coal is found around the globe, but three countries (the United States, the Soviet Union, and China) own nearly two-thirds of all known coal reserves. At present rates of consumpton, these reserves would last the world more than 200 years, according to conservative estimates. Furthermore, geologists think the world probably has 15 times this much coal.

While the United States has the largest share—more than a quarter—of the 786 billion tons of known world coal reserves, both the Soviet Union and China produce almost as much coal as we do.

In addition to the category of known reserves, the U.S. Geological Survey has calculated that the United States has an estimated 1.7 trillion tons of deposits at depths of less than 3,000 feet. Unfortunately, much of this coal is not accessible with present technology or at present prices.

United States coal mining began in the mid 1700s, but coal did not overtake wood as the major source of fuel until the 1880s. As recently as 1925, this country relied on coal for 70 percent of its energy. Coal was itself overtaken by both oil and gas in the late 1940's because they were cheaper and easier to transport.

In 1979 a quarter of a million miners labored in some 6,000 American mines scattered over 26 states. They produced 780 million tons of coal, two-fifths from underground mines found mostly east of the Mississippi and three-fifths from surface or strip mines in both the East and West. The cost: more than a hundred lives and thousands of injuries that year alone.

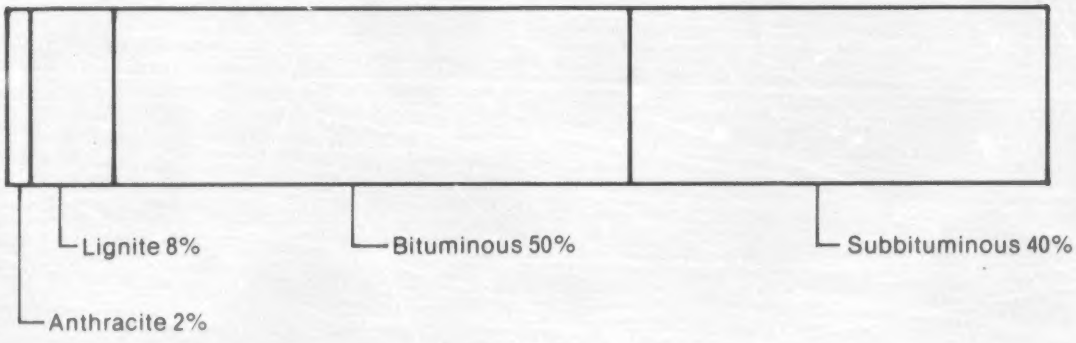
Old King Coal has been deposed by cleaner, more manageable fuels, and calling the United States the "Saudi Arabia of Coal" will not put the former monarch back on his throne. Our gritty black coal provides only a fifth of the energy we use each year. Of the 680 million tons of coal consumed in 1979, 77 percent was burned by electric utilities.

tackling problems

To produce and use substantially more coal than we do today, a number of problems will have to be tackled: capital shortages at high interest rates, manpower (potential strikes and declining productivity), and transportation including inadequate rail facilities. Environmental concerns include the proper reclamation of mine sites, potential changes in global climate caused by increased carbon dioxide from burning coal, and the emissions from coal stacks that erode buildings, poison lakes, and damage human lungs.

Typical Energy-Related Time Factors	Years
Building specialized mining equipment	5-8
Developing an underground coal mine	8-10
Development of an open pit mine	10-15
Approval, design, and construction of a nuclear power plant	10-15
Developing practical shale oil production	8-10
Developing geothermal production	7-10
Developing economical solar voltaic cell	10-40
Developing commercial fusion power	25-50

Coal Types by Share of U.S. Coal Reserves



Instructor Information...

Liquids from Coal

Rationale:

If coal is to bridge the energy gap, we must find efficient ways to use it. One way of making coal more usable is to change it into a liquid. This requires a chemical addition to coal and huge amounts of coal. At present the yield of a ton of coal to a barrel of oil is a drawback.

Objective:

Students will be able to read "Liquids from Coal" and discuss its feasibility as a future potential source of energy.

Implementation:

Hand out "Liquids from Coal" reading. Have students read individually or as a total class.

Debriefing:

The following questions may be useful in the discussion:

1. Why were the studies of the German technology set aside during the 1930's?
2. What has happened that makes coal liquefaction more attractive today?
3. How can coal be changed into a liquid?
4. What is a major drawback of changing coal from a solid to a liquid?
5. What types of chemicals can be made from coal? (Hint: examine the graphic)

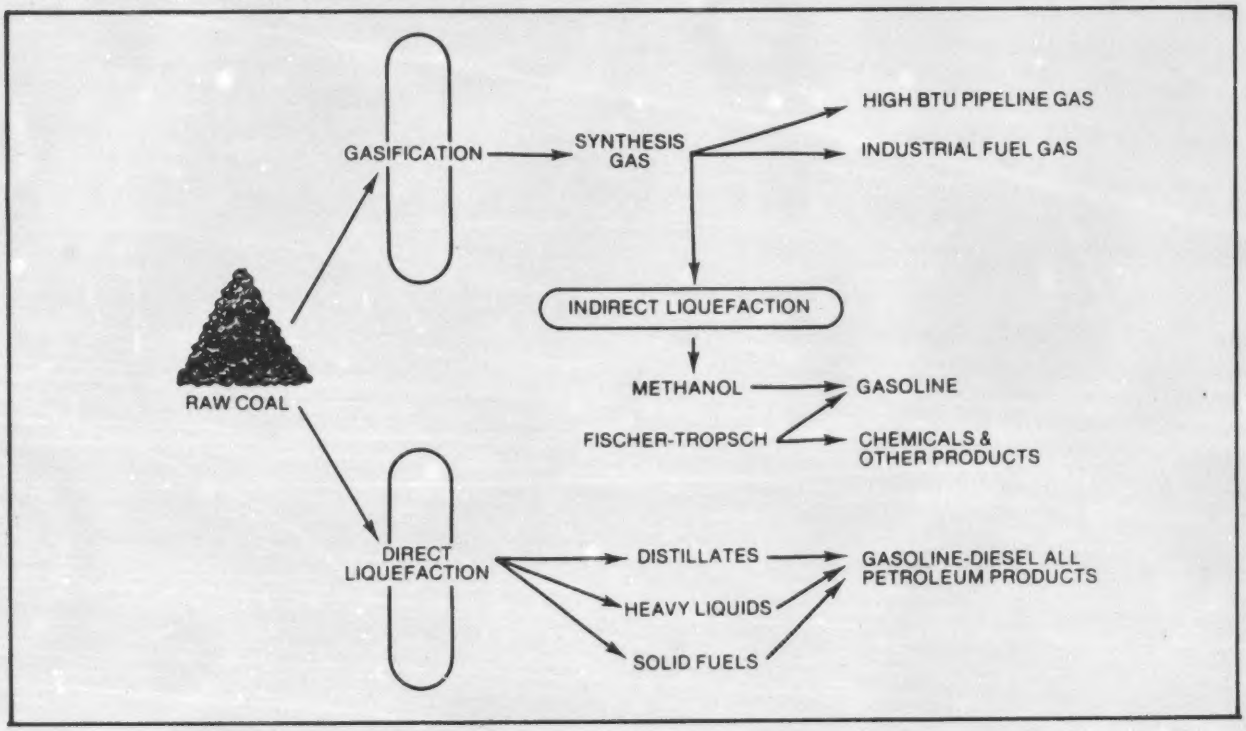
Name _____

Date _____

Liquids From Coal

Coal liquefaction is not new. Prior to World War II, a number of coal-to-liquid plants were built in Germany in anticipation that oil supplies might be cut off. Complex, bulky and expensive as they were, these processes helped fuel the German war machine.	the history of liquid coal
Small scale feasibility studies of German technology were conducted in the U.S. during the 1930s, but the effort was largely moot because of the discovery of cheaper East Texas oil in 1930. In 1944, U.S. interest revived somewhat, and Congress passed the Synthetic Liquids Fuels Act. The Act provided $85 million in research funds, and two experimental plants were built and operated until the program expired in 1955. Then, just as in 1930, another oil discovery killed interest in coal liquids. This time the find was in the Middle East.	experimentation
What appeared to be a cheap abundant energy source in the 1950s has today become the focal point of America's efforts to maintain its economic and national security. The near monopoly of foreign supplies caused the price of world oil to increase almost eight-fold in the decade of the 1970s. Even at today's prices—roughly $30-$35 a barrel—there is no assurance that portions of foreign supplies will continue to flow uninterrupted in the future, or that prices will not continue their upward spiral.	a new thrust uncertainty
In view of this, a domestic synthetic fuels industry, historically hindered by unfavorable economics, is now being viewed as vital to an energy-secure marketplace in the 1980s and beyond.	a restart
Solid coal consists mainly of carbon and ash and contains only small amounts of hydrogen, along with other elements such as sulfur, oxygen and nitrogen. Oil, on the other hand, is made up of molecules with a much higher proportion of hydrogen linked to its carbon atoms.	the principle
Therefore, the basic way to turn coal into oil is to increase the amount of hydrogen. Techniques for doing this vary widely. Costs and difficulties depend largely on what is required to reach the desired ratio between carbon and hydrogen atoms in the synthetic oil molecule. In general, the more hydrogen added, the "lighter" are the resulting liquids.	increasing hydrogen
There are three basic ways to change coal into liquid fuels: (1) break coal into two fractions: one that is rich in carbon (char) and one that retains most of the hydrogen (oil); (2) break coal apart with steam and oxygen to form a gas, then rebuild the gaseous molecules into liquids; or (3) add hydrogen directly to the coal.	changing coal into liquid fuel
The first approach is called "pyrolysis" or "carbonization." It may hold some potential, particularly since it is relatively simple, works at moderate temperatures and pressures, and produces two fuels: a heavy synthetic crude oil and char (which can be converted to gas). The drawback to date, however, has been the low yields of liquids, roughly a barrel or less per ton of coal.	a barrel per ton of coal
The major efforts in the U.S. to produce liquids from coal have focused on the other two methods commonly referred to as "indirect" and "direct" liquefaction techniques.	other techniques

The route from coal to oil can take several paths. Coal can first be gasified and then the gases changed to liquids by "indirect liquefaction" techniques, or coal can be converted directly to a liquid, bypassing the gasification step.



Instructor Information...

Gas from Coal—How is it Done?

Rationale:

Many of the processes of changing coal to various types of fuel are not new. Because of the high cost of oil, these processes are becoming more economically reasonable. There are still many problems in changing coal from its solid state.

Objective:

Students will be able to read "Gas from Coal—How is it Done?" and discuss its potential.

Implementation:

Hand out "Gas from Coal—How is it Done?" and read either individually or as a class.

Discuss the benefits and problems associated with this process.

Debriefing:

The following questions may be useful in the discussion:

1. How is coal changed into gas?
2. Why is the liquid coal process of little interest to large companies?
3. What are some problems associated with this process?
4. How might coal gasification compete with agriculture?
5. What transportation problems are there with coal?

Name _____

Date _____

Gas From Coal—How Is It Done

a chemical process

The basic chemical process is to react coal with water (as steam). The technique was discovered in the alchemists' laboratories as far back as 1780.

a 200-year old discovery

While the sizes and shapes of the equipment or the way heat is supplied to break the coal apart may change, the chemical transformations that take place in today's gasifiers are based on this 200-year old discovery.

crushing and drying

In actual practice, coal is first crushed and usually dried, then fed into a large vessel where it reacts with steam and either air or oxygen. The reaction usually occurs at high temperatures (from 1500 to 3500 degrees F, depending on the process) and high pressures (up to 1600 pounds per square inch).

a mixture of gases

Under these conditions, coal begins to break down, and hydrogen atoms from the steam, along with oxygen atoms begin to link up with carbon atoms of coal to produce a mixture of gases.

town gas

If air has been used, the gases also contain a high percentage of nitrogen and have a heating value roughly one-tenth that of natural gas—or about 100 Btu's per cubic foot. This relatively low heating value accounts for the name "low Btu" gas. In the 1930s it was called "town gas."

what are the obstacles?

Foremost is the high cost of the gas. None of the synthetic gas processes—even those using the most advanced technology—are yet able to compete in the United States with natural gas or petroleum at today's prices.

expensive plants

The synthetic gas plants themselves are also expensive. Even if companies could be assured that the price of synthetic gas could compete with other gas sources in the 1980s, a commercial 30,000 ton per day coal gasification project represents such a massive capital investment that even the largest of companies to date have balked.

different kinds of coal

Another obstacle is the coal itself. Unlike many areas of the world, the U.S. contains coals that vary widely with geographic region. Each type of coal displays different characteristics when subjected to the conditions required for gasification.

high sulfur coal

For example, most high-sulfur bituminous coals found in the eastern U.S. tend to swell and stick together when heated. The caked coal often clogs the gasifier shutting down the process.

western coal

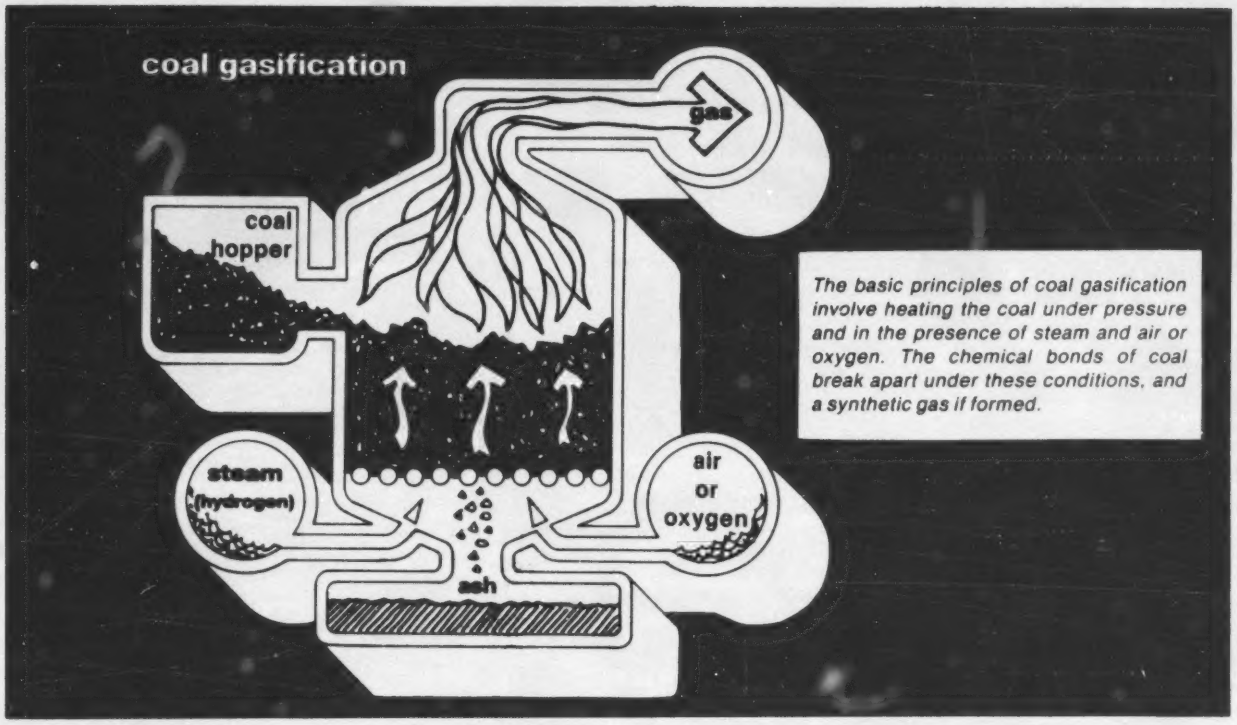
Western, sub-bituminous coals and lignites, on the other hand, gasify much more easily without caking. These coals behave similarly to those of Europe. Therefore, many of the gasifiers sold today overseas could find application in the western U.S.

coal's competition

But large-scale use of western coal may compete in some areas with agriculture, particularly in the use of sometimes scarce water. It may be possible, however, to use deep aquifers or water supplies unsuited for other purposes, or perhaps various water-conserving techniques to meet the demands of a western gasification project.

building transportation networks

Still, if western coal use is to increase, transportation networks must be extended to ship either the coal or the synthetic gas to the more populous, industrial sectors of the Nation. And special attention must be paid to the impact coal gasification plants will have on communities unaccustomed to the rapid influx of the thousands of workers that will be needed.



The basic principles of coal gasification involve heating the coal under pressure and in the presence of steam and air or oxygen. The chemical bonds of coal break apart under these conditions, and a synthetic gas if formed.

Instructor Information...

The North Omaha Coal-Fired Power Plant
Slide Presentation

Background Information

Coal is used as a fuel chiefly in the production of electricity. Electric power plants use more than two-thirds of the coal mined in the United States.

The great majority of electric power plants are steam-turbine plants. All nuclear power plants and almost all plants fueled by coal, gas, or oil are steam turbine plants. They use high pressure steam to generate electricity. The steam spins the wheels of turbines, which drive the generators that produce electricity. Steam-turbine plants differ mainly in how they create the heat to make steam. Nuclear plants create the heat by splitting uranium atoms. The other plants burn coal, gas or fuel oil. Steam-turbine plants provide about 80 percent of the electricity used in the United States. Coal-burning plants account for most of this output.

Instructor Information...

The North Omaha Coal-Fired Power Plant

I. Introduction

This slide program allows you to take a visual tour through the North Omaha coal-fired power plant. It was designed as a media supplement to the **Basic Teaching Unit**, "Coal: Fuel of the Past, Hope of the Future." It may also be used in a comparative sense with the **Basic Teaching Unit**, "Energy From the Atom." This particular slide presentation is approximately 20-30 minutes in length.

A. Purpose Statements

1. To introduce students to a visual display of a coal-fired power plant.
2. To have students observe the basic components of the coal-fired plant.

B. Objectives

After viewing the slide series, the student will be able to:

1. recognize the major features of a coal-fired power plant; and
2. realize the problems associated with the construction and operation of this type of power generating facility.

C. Provocative Questions

1. **Fly ash is a waste product of coal burning. What are some products made from fly ash?** (Some products made from fly ash are asphalt paving, cement and concrete blocks).
2. **What is a commonality among the nuclear power plant and the coal-fired power plant?** (They both use water (Missouri River) for cooling purposes.)
3. **What is produced from the burning of coal?** (Steam is produced from the burning of coal.)
4. **How can air pollution of a coal-fired plant be controlled?** (The air pollution of a coal-fired plant can be controlled by expensive pollution control devices. These reduce the emission of pollutants into the atmosphere).
5. **What other fuels can be developed from coal?** (Coal can be changed into a liquid fuel or gas).

Instructor Information...

D. **Available Resources**

Should you or your students wish to follow up this program, the following types of resources are available from the Nebraska Energy Office:

1. **Brochures**
   a. Energy Info . . . A Directory of Publications and Audio-Visual Material from the Nebraska Energy Office
   b. Energy Technology
   c. Gas from Coal
   d. Liquid from Coal
2. **Human**
   Public Information Officer
   North Omaha Power Station
   Omaha Public Power District
   1623 Harney Street
   Omaha, NE 68102

E. **Essential Advanced Preparation**

1. Slide carousel and projector
2. Read BTU, "Coal: Fuel of the Past, Hope of the Future" and the available resources mentioned.
3. **Human**
   Public Information Officer
   North Omaha Power Station
   Omaha Public Power District
   1623 Harney Street
   Omaha, NE 68102

Instructor Information...

Narrative for Slides of North Omaha Power Station

1. This is a coal-fired power plant located in North Omaha. A coal-fired plant is distinguished by its characteristic smokestacks. This picture was taken before the new 200-foot stacks were added to supplement the plants original pollution control equipment.
2. A view of the plant from the Missouri River.
3. The height of the stacks is limited to 200 feet due to the nearness of Eppley Airport.
4. Chart showing the capacity (output) of the 5 units. Total output is approximately 600,000 kw (kilowatts).
5. Unloading the coal from the unit train at the shaker house. A low-sulfur coal from Wyoming is used. The coal storage yard has a capacity of 900,000 tons. Over 6,000 tons are burned daily at maximum output.
6. Coal crusher house where the coal is either put in storage or crushed to a size more suitable for the pulverizers.
7. Storage of fly ash, a waste product of coal burning. Electrostatic precipitators are used to remove the waste ash. Much of the ash is used in asphalt paving, cement, and the manufacture of concrete blocks.
8. Conveyor belt system takes the coal into the plant. Magnetic pulleys remove the particles or iron.
9. Diagram of reheat steam generator (notice the man below the bunker on right-hand side).
10. This section houses five coal bunkers and steam generators. They are 12 to 13 stories high.

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11. Fire inside the boiler (steam generator).
12. Another view of the steam generator.
13. As is true of a nuclear plant, the coal plant uses water (Missouri River) for cooling purposes.
14. The water intake has a screen to prevent debris from entering.
15. Water usage chart.
16. Five of the water pumps.
17. Same—another view.
18. Diagram illustrating turbines and generators.
19. A view of the turbine-generator building, 484 feet long, where electricity is produced by five turbo-generators with a combined capability of 69.600 kw (kilowatts).
20. Some typical tools used on the turbines.
21. Other tools used.
22. Control room.
23. A computer built into the unit data, makes performance calculations, and detects abnormal operating conditions.
24. Electrical control panels.
25. The five-unit graphing machines.
26. Example of a graphing machine for unit #2.
27. Control panel.
28. Lab-testing respiration and photosynthesis.
29. Lab technician. Modern methods are used for water treatment/control and for testing coal and other materials.

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30. Lab fume hood.
31. Water testing lab; these rock baskets are used for taking samples of the organisms on the river bottom.
32. Transformers; power generated at 13,800, 15,000, or 20,000 volts and boosted to 69,000 and 161,000 volts for transmission.
33. Electricity begins its journey to OPPD customers from this substation adjacent to the generating plant.
34. Transmission lines.
35. OPPD maintains a continuous effort to protect the quality of the environment in its operations, as well as in its planning and construction.

Supplemental Materials Guide

Book

Energy: Global Prospects 1985-2000. Wilson, Carroll L. The Nimrod Press, 1977.

Pamphlets

Coal. **World Book**-Childcraft International, Inc. Chicago, 1979.

Coal Makes A Comeback. New England Electric, Massachusetts.

Gas From Coal—A Fossil Energy Fact Sheet. U.S. Department of Energy, June, 1980.

Liquids From Coal—A Fossil Energy Fact Sheet. U.S. Department of Energy.

Supplemental Energy Sources. American Petroleum Institute, Washington, D.C.

Teacher's Guide for the Energy Store. Gary Lay and Larry Scharmann, Nebraska Energy Office.

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